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RESEARCH PAPER

Behind Recycling Policies: An Exploratory Study on Psychological and Contextual Determinants of Waste Sorting Behaviour at University

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Abstract

Improper waste disposal has environmental and socio-economic costs, yet policies to address this issue often fail to effectively promote recycling. Much previous research has focused on household recycling, overlooking the fact that people spend much of their time in public spaces, where behaviours and barriers differ. This study examines the psychological and contextual determinants of waste-sorting behaviour among individuals studying and working at the University of Florence, adopting the Fogg Behavioural Model (FBM) as the guiding theoretical framework. Using a mixed-methods approach, we combined quantitative survey data from 482 participants with qualitative insights collected through open-ended responses to identify both barriers and facilitators of sorting behaviour in public spaces. The survey assessed antecedents such as self- and collective efficacy, social and personal norms, trust in the recycling process, and contextual obstacles. Results show that sorting behaviour is positively associated with norms, trust, and efficacy beliefs, and negatively influenced by contextual barriers such as limited access to recycling stations and unclear labelling. The qualitative findings further highlight the need for improved visibility, clearer signage, and expanded waste fractions on campus. Overall, the study underscores that effective recycling in public settings requires addressing both psychological drivers and structural barriers. In collaboration with the University's Green Office and the local waste

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management provider, these findings will inform future policy design and implementation, with potential applicability to other public institutions.

Keywords Waste · Sorting · Behaviour · University · Interventions · Barriers

JEL Classification A13 · D04 · D91 · Q53

1 Introduction

Waste is a major driver of environmental degradation, contributing both to resource depletion and pollution (Minelgaitė & Liobikienė, 2019a, 2019b). Improper disposal generates a wide range of harmful effects, from direct consequences such as soil and water contamination to indirect impacts associated with the overaccumulation of waste in landfills and incinerators (Heidari et al. 2018; Matsuda et al. 2018). Waste management is not only an environmental challenge but also a behavioural one. Although technological advances and efficient collection systems are necessary, their success ultimately depends on citizen participation and compliance with proper waste segregation (Knickmeyer 2020). Higher levels of participation improve the quality of recycled materials, leading to more efficient processes overall (Pluskal et al. 2021). While many countries have introduced regulations and developed waste collection systems, their effectiveness has been mixed (Andersson & Stage 2018; Timlett & Williams 2008). This highlights the need for interventions and policies that go beyond structural solutions and incorporate behavioural insights to design more effective and context-sensitive recycling systems.

Public spaces face persistent challenges with waste management, particularly low recycling rates and improper waste sorting (Wan et al. 2012). Italian universities represent a critical setting in this regard. Not only they generate significant amounts of waste, serving nearly 2 million students and over 160,000 staff (USTAT 2023), but they also function both as environments where sorting practices can be tested and improved and as institutions that prepare future professionals to design sustainable policies (Guerrero et al. 2013). Recycling is a key aspect of waste management in such spaces, as it reduces dependence on landfills and incineration and can indirectly lower greenhouse gas (GHG) emissions across other sectors, even though the waste sector itself accounts for only about 3% of total EU emissions (EEA 2024). Yet, despite initiatives such as the Waste Framework Directive (Directive 2008 /98/EC, (2024)), municipal waste volumes have continued to rise, and recycling performance remains inadequate in many contexts (Eurostat 2024; ISPRA 2023). Investigating recycling interventions in universities thus provides an opportunity to understand behavioural drivers of waste sorting and to develop strategies that foster sustainable practices on campuses, enabling them to serve as models for broader societal change (Lotti et al. 2023).

In reality, existing interventions often lack grounding in the specific contexts where they are applied and rely heavily on previous literature rather than real-world needs and challenges (Varotto & Spagnolli 2017). To address this gap, the present study develops a comprehensive survey that integrates quantitative analyses of recycling behaviour

with qualitative insights, aiming to inform the design of effective interventions in public spaces. Specifically, we pursue two aims: first, to create a survey adaptable across contexts, with a primary focus on Italian universities but extendable to other workplaces; and second, to identify the barriers that prevent regular visitors from recycling at the University of Florence. By combining quantitative data with qualitative approaches such as open-ended questions, we capture context-specific behavioural drivers that are often overlooked in purely economic analyses, thereby providing a more holistic understanding of recycling barriers. In partnership with the University's Green Office and its waste management provider, this work brings together academic research and practical strategies to improve waste management on campus and embed behavioural evidence into sustainability policy.

To guide our investigation, we applied the Fogg Behaviour Model (FBM; Fogg 2009), which posits that behaviour depends on motivation, ability, and prompts. Accordingly, our survey examines barriers related to ability (e.g., access to facilities), prompts (e.g., bin placement and visibility), and motivation (e.g., personal responsibility and social norms). We also include broader antecedents of sorting behaviour, such as information availability, personal norms, and perceptions of climate change risk. Given the exploratory nature of this work, we did not formulate hypotheses but instead defined two research questions:

1. What contextual barriers influence recycling behaviour in public spaces, and which solutions are perceived as beneficial?
2. How do psychological factors such as personal norms, perceptions of climate change risk, and efficacy beliefs support recycling practices, particularly at the University of Florence?

The remainder of this paper is structured as follows. The Literature Review surveys existing research on recycling behaviour in public and institutional settings, with particular attention to universities and the theoretical frameworks used to study such behaviour. The Methods section describes the study setting, survey design, and analytical approach. The Results section presents findings on current recycling behaviours, perceived barriers, and attitudes across staff and student groups. The Discussion interprets these findings in light of the FBM framework and the existing literature. The paper closes with a Conclusion that outlines practical recommendations for university waste management and directions for future research.

2 Literature Review

The effectiveness of waste management depends not only on infrastructure and policies but also on public engagement and behavioural factors. Research has increasingly focused on the role of individuals and institutions in shaping waste-related behaviours and policies (Raghu & Rodrigues 2020). For example, Guerrero and colleagues (2013) reviewed studies from developing countries across four continents and identified multiple stakeholders as central to waste management: national and local governments, private contractors, service users, and waste collection workers. They argue that effective policies for sustainable waste management systems must ensure open

communication, reliable data, and well-established information channels among these groups to maintain cooperation. In this view, waste management is not only a technical challenge but also a governance issue requiring coordinated policy frameworks (Guerrero et al. 2013).

At the same time, policy success also depends on individual engagement, prompting extensive research on how to encourage recycling within these broader systems. Strategies range from providing feedback (Dupré & Meineri 2016; Mertens & Schultz 2021; Schultz 1999), social modelling and environmental alterations (Varotto & Spagnolli 2017), awareness-raising campaigns (Evison & Read 2001; Nixon & Saphores 2009; Welfens et al. 2016), to monetary and non-monetary incentives (Iyer & Kashyap 2007; Li et al. 2021). Despite these efforts, there is still debate on how best to motivate individuals to sort their waste, as the behaviour is constrained by multiple challenges in daily life, including limited motivation, time, and resources.

While many studies have focused on household recycling, people also spend substantial time in public settings such as workplaces and universities, where contextual factors shape both the challenges and incentives to recycle. Several barriers to pro-environmental behaviour are context-dependent, helping to explain why recycling rates are often lower at work than at home, even among the same individuals (Andersson et al. 2005; Stern et al. 1999; Lee et al. 1995). Contextual influences include differences in responsibility, convenience, access to facilities, and social norms (Yuriev et al. 2018). Workplace studies illustrate how organisational and social factors can foster recycling. For instance, Costa et al. (2022) showed that a 'green' organisational climate promotes waste separation through attitudes, subjective norms, and perceived behavioural control, with supervisor support further reinforcing these effects.

Universities represent a distinctive public setting for studying recycling behaviour, combining high waste generation with an educational mission. Survey research in higher education has highlighted multiple factors shaping recycling. Kelly et al. (2006) surveyed 1,400 students and staff at Massey University, New Zealand, showing generally positive recycling attitudes and behaviour, with improvements linked to better signage and expanded access to recycling points. Wan et al., (2012), in Hong Kong, similarly found that recycling intentions on campus are influenced by attitudes, subjective norms, perceived behavioural control, awareness of consequences, moral norms, and convenience, suggesting that educational and promotional programmes can enhance both motivation and facility use. Internal factors such as motivation, perceived consumer effectiveness, gender, and environmental knowledge also influence recycling habits, as shown in studies in Spain and the USA (Izagirre-Olaizola et al. 2015). In particular, knowledge plays a critical role, with both declarative knowledge (knowing what to recycle) and procedural knowledge (knowing how to recycle) shaping behaviour (ten Berge & van Hezewijk 1999; Andersson & Von Borgstede 2010; Ng 2023). Sallaku et al. (2020) systematically reviewed recycling in higher education institutions and identified the most common antecedents of recycling behaviour, including environmental concern, social norms, institutional policies, and availability of facilities. These findings highlight that, as in workplaces, both contextual and individual factors interact to determine recycling behaviour, making universities a valuable setting for testing and designing interventions.

While many studies have used the Theory of Planned Behaviour (TPB; Ajzen 1991) as a theoretical background for recycling (Cohen et al. 2025; Waxin et al. 2025), we adopted the Fogg Behavioural Model (FBM; Fogg 2009) because of its explicit treatment of prompts as a necessary condition for behaviour. Although TPB captures motivational constructs well, and perceived behavioural control overlaps with FBM's notion of ability, FBM goes further by treating the prompt — the situational cue that triggers action at the right moment — as an independent and essential component, not merely a facilitator of intention. This distinction is particularly relevant in waste sorting contexts, where individuals may hold positive attitudes and know what to do, yet still fail to act correctly without a well-placed cue (Zhang et al. 2019; Wang et al. 2020; Etim 2024). Intention alone is often insufficient, as practical and contextual factors act as barriers or facilitators (Wu et al. 2018; Rosenthal & Linder 2021). By structuring our inquiry around motivation, ability, and prompts, we were able to link reported barriers directly to targeted solutions, including the physical and informational prompts that form the core of our proposed intervention (see Table 1).

3 Methods

The study adopted a cross-sectional survey design and was informed by the FBM (Fogg 2009), which posits that behaviour results from the interaction of motivation, ability, and prompts. In the present study, barriers and facilitators to recycling were conceptualised as contextual factors influencing all three FBM components: ability (e.g., access to recycling facilities, clarity of labels), motivation (e.g., personal norms, social responsibility), and prompts (e.g., visibility and placement of bins, potential interventions). This theoretical framework guided both the selection of constructs measured in the survey and the design of survey items (barriers and facilitators), ensuring that questions captured factors relevant to motivation, ability, and prompts. By linking survey measures explicitly to the FBM, we aimed to provide a framework for interpreting which contextual and psychological factors support or hinder recycling behaviour in university settings.

3.1 Participants and procedure

Participants (N = 641) were recruited among individuals studying or working at the University of Florence (students, researchers, administrative, and academic staff). After removing responses from participants who did not consent or did not complete the survey, a total of N = 482 responses were analysed. The survey was initially distributed via a university mailing list. Data collection was then expanded to include snowball sampling and the personal networks of participating researchers, as well as outreach to other interest groups for sharing (student associations and informal groups of researchers).

The survey was administered through Qualtrics and made available in both English and Italian. Participants accessed the survey via a single anonymous link. The survey opened in English by default, but participants could switch to the Italian version using

Table 1 Association of FBM dimensions with barriers and solutions of the present study

FBM dimensions	Barriers	Solutions
Prompt		
	BARR1: The labels on the containers are not clear	Improving the clarity of labels on the bins
	BARR2: I do not know where the recycling bins are, so I use the first bin I can find	Making the recycling area more pleasing/attractive Increasing the visibility of recycling areas
	BARR3: The containers do not stand out enough	Making the recycling area more pleasing/attractive Increasing the visibility of recycling areas
Ability		
	BARR4: I lack the information to recycle correctly, e.g., what goes where	Receiving more information on how to recycle Improving the clarity of labels on the bins
	BARR5: The recycling bins are too far from my classroom/office	Having access to recycling bins in my office/classroom
	BARR6: The recycling bins I need for my typical waste are not available	Having access to recycling bins in my office/classroom
Motivation		
	BARR7: The people around me do not think that recycling is important	Knowing that others also make the effort of recycling
	BARR8: I think recycling in public areas (e.g. university, office etc.) is not my responsibility	Receive more information on how waste is handled
	BARR9: I lack the motivation to recycle in the university/public places	Knowing that others also make the effort of recycling

the dropdown menu on the landing page. (*"Usa il bottone a destra per aprire la versione in italiano"*). Upon entering, participants were first presented with a consent form. Those who did not consent were immediately redirected to exit the survey; those who agreed could proceed to the study questions. In accordance with the REC's guidelines on participant rights, no question required a forced response, allowing participants to skip any item if they wished.

3.2 Materials

The survey included both validated measures and ad hoc questions developed for this study. Where validated instruments existed for the psychological constructs of interest, namely collective and self-efficacy (Tam, 2014), risk perception of climate change (Van der Linden 2015), and social desirability (Bobbio & Manganelli 2011; Paulhus, 1991), we adopted and adapted them. For constructs where no validated measure was available

that adequately captured the specific context of university recycling behaviour, we developed ad hoc items grounded in the existing literature and tailored to the study setting. These included personal norms, recycling knowledge, environmental values, trust in the recycling process, and contextual barriers and facilitators. Demographic items were also included (see Appendix A for the complete item list). The full survey can be found on OSF: https://osf.io/zjtwe.

Differences in scale length reflected methodological considerations: validated instruments were retained in their original 7-point formats to ensure comparability with prior research, with minor adaptations where needed for consistency across the survey, while ad hoc items used 5-point scales to simplify response options and reduce participant burden (Revilla et al. 2014).

3.2.1 Ad hoc measures

Contextual barriers were measured with 9 items on a 5-point scale (1 = Completely disagree, 5 = Completely agree), each describing a potential obstacle to recycling at the university (e.g., "The labels on the containers are not clear"). Higher scores indicated stronger perceived barriers. Participants could also provide additional barriers in an open-ended response. Possible solutions were assessed in two formats: a multiple-choice question (participants selected which solutions might encourage them to recycle more) and items describing potential improvements, rated on the same 5-point agreement scale (e.g., "Increasing the visibility of recycling areas"). Personal norms were measured with 3 items on a 5-point scale (1 = Strongly disagree, 5 = Strongly agree). Recycling knowledge and beliefs about human obligation toward the environment were measured with 3 and 2 items, respectively, on a 5-point scale (1 = Completely disagree, 5 = Completely agree). Trust in the recycling process was measured with one item on a 5-point scale (1 = Not at all, 5 = Completely), followed by an open-ended question asking what participants believe happens to their recycled waste. Recycling behaviour was measured with a single self-report item on a 5-point scale (1 = Never, 5 = Always).

3.2.2 Validated measures

Collective and self-efficacy were assessed with two 4-item scales adapted from Tam (2014). These were retained in their original 7-point format (1 = Strongly disagree, 7 = Strongly agree), with minor wording changes to fit the recycling context (e.g., "My actions in recycling can have a meaningful impact," adapted from "My actions in protecting nature can have a meaningful impact"). Risk perception of climate change (RPCC) was measured with the 8-item RPCC scale (Van der Linden 2015), also retained in its original 7-point format with item-specific endpoints (e.g., "How serious a threat do you think that climate change is to the natural environment?" ranged from 1 = Not serious at all, 7 = Very serious). Social desirability was measured using the Impression Management (IM) subscale of the BIDR-16 (Bobbio & Manganelli 2011; Paulhus, 1991). We used the eight IM items but adapted the response format to a 5-point scale (1 = Completely disagree, 5 = Completely agree), rather than the original 6-point format, to harmonise with the majority of scales in the survey and to

enhance ease of comprehension. An example item was: "I always obey laws, even if I'm unlikely to get caught."

3.2.3 Demographics

The survey also included demographic questions on age, gender, political orientation, country of origin, university role (e.g., student, academic staff, administrative/support staff, service staff), and primary workplace (campus/building).

3.3 Ethics Statement

The study received approval from the Research Ethics Committee (REC) at the University of Florence (Protocol number: 0173384). Participants provided their informed consent at the beginning of the survey (see Sect. 3.1 "Participants and procedure"). No deception or hidden purposes were used, and all information about the study was fully disclosed. The study was pre-registered on the OSF repository, accessible here: https://osf.io/7p4zn/.

4 Results

4.1 Qualitative results

The survey received 482 valid responses from students, administrative staff and faculty. Here, we focus on the perceived barriers and possible solutions to improve recycling behaviour on campus. Of the respondents, 196 students participated, but only 22 added feedback in the open text for sorting barriers, with 5 offering solutions. 223 administrative and teaching staff reported 56 barriers, with 39 suggesting possible improvements. It appears that those for whom the university is a workplace have more opinions and suggestions than students who visit the university for classes and exams for a limited time.

Regarding open questions for barriers, the most common was the limited availability of bins, with 40 mentions. Respondents indicated that while bins for paper and packaging are generally available, they are often less conveniently located than residual waste bins, resulting in recyclable materials being thrown away with general waste. Many also noted the lack of organic and glass recycling bins, particularly in food areas, where they would be most useful. Communication issues were cited by 14 people, pointing to the need for clearer guidance on how to recycle correctly.

In terms of suggested solutions, increasing the visibility and accessibility of recycling points emerged as the top priority, with 468 responses, highlighting a clear demand for infrastructural improvements. The need for better information on waste management and how to recycle ("knowing how") is also important, with 386 and 368 responses, respectively. In addition, 314 people highlighted the importance of clearer labelling on recycling bins to avoid confusion. Finally, 286 respondents suggested

improving access to recycling bins in offices and classrooms, highlighting the importance of convenience in encouraging recycling. Some qualitative responses, including 16 suggestions, pointed to the need to add more recycling fractions, such as bins for organic waste and glass.

4.2 Quantitative results

The full materials, including dataset and analysis script can be found on OSF: https://osf.io/zjtwe. The demographic characteristics of the sample are displayed in Table 2. A total of 482 participants completed the survey. Most respondents were female (62.9%), followed by males (32.8%), while 1% identified as non-binary and 3.1% preferred not to disclose their gender. Political orientation was skewed toward the left, with 54.4% of participants identifying as very or somewhat left-wing ("liberal" in the English translation). A large proportion (25.9%) did not disclose their political orientation, a pattern that was expected given the sensitive nature of the question. University employees (both administrative and academic staff) represented the largest share of the sample (58.9%), while students were 40.7%.

First, we examined the descriptive statistics of the aggregated measures, including the barriers and the psychological factors. The scales indicate generally high levels of self-reported recycling behaviour (M = 4.35 on a 5-point scale), suggesting a high

Table 2 Demographic characteristics of survey respondents (N = 482)

Variable	N (%)
Age	
Mean (SD)	37.5 (15.1)
Median [Min, Max]	35 [18, 69]
Gender	
Male	158 (32.8)
Female	303 (62.9)
Non-binary	5 (1.0)
Prefer not to say	15 (3.1)
Missing	1 (0.2)
Political Orientation	
Left	262 (54.4)
Centre	57 (11.8)
Right	32 (6.6)
Other/Prefer not to say	125 (25.9)
Missing	6 (1.2)
Occupation	
Student	196 (40.7)
Employee (research or admin)	284 (58.9)
Missing	2 (0.4)

pro-environmental orientation among participants. Perceived barriers show moderate variability (M = 2.19; SD = 0.67 on a 5-point scale), indicating that some structural or contextual obstacles are commonly experienced. Notably, self-efficacy (M = 5.55 on a 7-point scale) and personal norms (M = 4.3 on a 5-point scale) scored relatively high, reflecting a strong sense of moral obligation and confidence in one's ability to recycle Table 3.

As we did not formulate hypotheses in advance, we conducted two exploratory correlation analyses. The first matrix (Table 4) examined individual barriers (Bar1–Bar9) in relation to self-reported recycling behaviour (BEH), while the second (Table 5) included aggregated psychological scales, aggregated barriers, and reported behaviour. All the nine individual barriers showed negative associations with recycling, indicating that the more strongly participants perceived a barrier, the less likely they were to recycle at the university. We also examined intercorrelations among the barriers to assess internal consistency and to identify clusters of barriers that might co-occur. This analysis is not only useful for preparing subsequent regression models but also has practical implications: if certain barriers are highly correlated, tackling one may indirectly reduce others. For instance, Bar2 ("I do not know where the recycling bins are, so I use the first bin I can find"), Bar3 ("The containers do not stand out enough"), and Bar5 ("The recycling bins are too far from my classroom/office") were especially strongly related to each other and to behaviour. These barriers all concern the visibility and accessibility of bins, suggesting that targeted interventions to make recycling stations more salient and conveniently located could simultaneously reduce multiple barriers (see Table 1 for the complete list of barriers).

When examining the aggregated scales, we found a strong negative relationship between total barriers and recycling behaviour, consistent with the negative correlations observed for most individual barriers (except for Bar7). In contrast, all other measured psychological factors were positively associated with reported recycling, although the strength of these correlations varied. Self-efficacy (SETOT) and personal norms (PNormsTOT) showed the strongest positive associations with sorting behaviour, while collective efficacy (CETOT), risk perception of climate change (RPTOT), belief in human responsibility to protect nature (HTOT), and recycling knowledge (InfoTOT) exhibited weaker but still significant positive correlations. Barriers were negatively related not only to recycling behaviour but also to most psychological factors that typically support pro-environmental actions, and most of these factors were positively correlated with one another. Risk perception and recycling knowledge did not consistently follow this pattern, suggesting a less influential role in shaping recycling behaviour in this context. Social desirability, measured via the BIDR scale, also showed correlations with the main variables. It was positively associated with reported recycling and negatively with perceived barriers, indicating that participants with higher social desirability may report fewer barriers and higher recycling behaviour. However, self-report data cannot distinguish actual behaviour from a tendency to respond in socially desirable ways.

To better understand the predictors of recycling behaviour, we ran a linear regression with perceived barriers, self-efficacy, and personal norms as predictors. Results (Table 6) indicate that perceived barriers significantly reduced recycling behaviour ($\beta = -0.045$, $p < 0.001$), while self-efficacy ($\beta = 0.022$, $p = 0.016$) and personal norms

Table 3 Descriptive statistics for all study variables (N = 482)

	BEH	BarriersTOT	BIDRTOT	RPTOT	SETOT	CETOT	InfoTOT	PNormTOT	HTOT
Mean	4.35	2.19	3.66	5.97	5.55	5.38	3.69	4.29	4.64
SD	0.881	0.676	0.738	1.03	1.13	1.03	0.586	0.776	0.587

For item−level details, see Appendix A. *BEH* recycling behaviour; *BarriersTOT* perceived barriers; *BIDR* social desirability; *RP* risk perception; *SE* self−efficacy; *CE* collective efficacy; *Info* information; *PNorm* personal norms; *H* human nature

Table 4 Correlation matrix of barriers and behaviour

	BEH	Bar1	Bar2	Bar3	Bar4	Bar5	Bar6	Bar7	Bar8	Bar9
Bar1	- 0.126**									
Bar2	- 0.406***	0.287***								
Bar3	- 0.343***	0.308***	0.608***							
Bar4	- 0.118**	0.280***	0.237***	0.256***						
Bar5	- 0.366***	0.251***	0.484***	0.506***	0.221***					
Bar6	- 0.225***	0.237***	0.379***	0.435***	0.196***	0.386***				
Bar7	0.005	0.028	0.129**	0.179***	0.193***	0.119**	0.100*			
Bar8	- 0.143**	0.050	0.200***	0.143**	0.129**	0.143**	0.042	0.060		
Bar9	- 0.202***	0.105*	0.255***	0.184***	0.114*	0.214***	0.118**	0.088	0.561***	
Barriers TOT	- 0.379***	0.538***	0.724***	0.741***	0.538***	0.672***	0.604***	0.396***	0.353***	0.437***

Pearson correlations between perceived barriers (Bar1–Bar9) and self−reported recycling behaviour (BEH).
Negative values indicate that higher perceived barriers are associated with lower recycling behaviour.
*df = 480; * p < .05, ** p < .01, *** p < .001*

Table 5 Correlation matrix of full scales on behaviour

	BEH	Barriers TOT	BIDRTOT	RPTOT	SETOT	CETOT	InfoTOT	HTOT
Barriers TOT	- 0.379***							
BIDRTOT	0.184***	- 0.261***						
RPTOT	0.151***	- 0.099*	0.060					
SETOT	0.280***	- 0.266***	0.258***	0.252***				
CETOT	0.188***	- 0.228***	0.196***	0.236***	0.765***			
InfoTOT	0.163***	- 0.148**	0.137**	0.032	0.182***	0.087		
HTOT	0.220***	- 0.242***	0.204***	0.419***	0.312***	0.208***	0.232***	
PNormTOT	0.304***	- 0.200***	0.155***	0.355***	0.445***	0.339***	0.159***	0.288***

Pearson correlations among psychological predictors — social desirability (BIDR), risk perception (RP), self−efficacy (SE), collective efficacy (CE), information (INFO), human nature (H), and personal norms (PNORM) — perceived barriers (BarriersTOT), and self−reported recycling behaviour (BEH).

*$* p < .05$, **$ p < .01$, ***$ p < .001$*

Table 6 Linear regression predicting recycling behaviour from perceived barriers, self-efficacy, and personal norms

Predictor	Model Estimate (SE)
Barriers (BarriersTOT)	- 0.045*** (0.006)
Self-Efficacy (SETOT)	0.022* (0.009)
Personal Norms (PNormTOT)	0.073*** (0.017)
Constant	3.82*** (0.29)
N = 482 $R^2 = 0.208$	

Perceived barriers negatively predict recycling behaviour, while self−efficacy
and personal norms are positive predictors.
The model explains 20.8% of the variance.
** p < .05, ** p < .01, *** p < .001*

($\beta = 0.073$, $p < 0.001$) were positively associated. The model explained approximately 20.8% of the variance in reported recycling ($R^2 = 0.208$), highlighting the substantial role of these factors.

We also estimated a series of hierarchical models to assess robustness. Model 1 included only barriers; Model 2 added self-efficacy and personal norms; and Model 3 further included BIDR and demographic controls (age and gender). In Model 3, the inclusion of BIDR led to only a negligible increase in explained variance ($\Delta R^2 = 0.005$), and BIDR was not statistically significant ($B = 0.09$, $p = 0.104$). Importantly, the barriers that were significant in the initial model (Bar2, Bar5, and Bar7) remained significant with very similar effect sizes, and the overall pattern of results was unchanged (see Appendix B for additional details on Models 1 and 3). Across all specifications, the main predictors retained their significance and direction, while the incremental variance explained by BIDR and demographics was minimal. Other potential regressors did not meaningfully improve adjusted R^2, and for parsimony, we focus on the core model in the manuscript. These analyses indicate that perceived barriers, self-efficacy, and personal norms play a substantial and independent role in predicting recycling behaviour, whereas social desirability does not exert an independent effect.

Because self-efficacy emerged as a particularly strong predictor in both the correlation matrix and the regression analyses, we tested a mediation model (Fig. 1) to examine whether perceived barriers help explain the link between self-efficacy and recycling behaviour. This analysis focused on identifying key predictors and testing the mediating role of barriers in a parsimonious framework. The estimates indicate that higher self-efficacy predicts fewer perceived barriers, which in turn relate to more frequent recycling behaviour (Tables 7 and 8). The direct effect of self-efficacy on behaviour is also significant, and both the total and indirect effects are significant, indicating that self-efficacy impacts behaviour both directly and indirectly through its effect on perceived barriers.

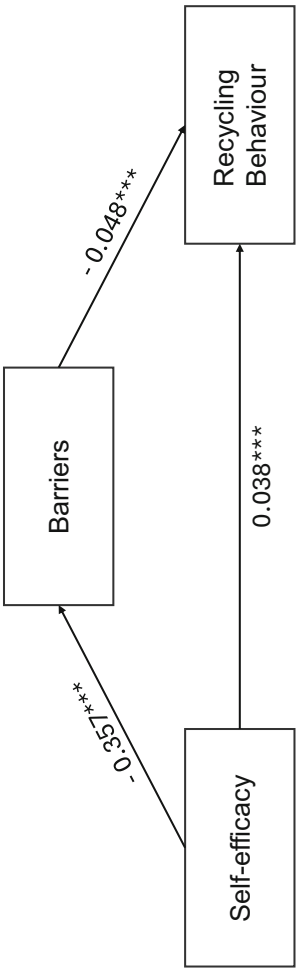

Fig. 1 Mediation model illustrating the effect of self-efficacy on recycling behaviour through barriers

Table 7 Mediation analysis: perceived barriers as mediator of the relationship between self-efficacy and recycling behaviour

Effect	Estimate (SE)
Indirect	0.017*** (0.004)
Direct	0.037*** (0.008)
Total	0.054*** (0.009)
N = 482	

Self−efficacy predicted recycling behaviour both directly and indirectly through reduced barrier perception.
*$p < .05$, **$p < .01$, ***$p < .001$

Table 8 Path estimates for the mediation model of self-efficacy, perceived barriers, and recycling behaviour

	Estimate	**SE**	**Z**	**p**
SETOT → Barriers TOT	- 0.357	0.06	- 6.07	< 0.001
Barriers TOT → BEH	- 0.048	0.01	- 7.66	< 0.001
SETOT → BEH	0.038	0.01	4.50	< 0.001

Self−efficacy negatively predicted perceived barriers, which in turn negatively predicted recycling behaviour; a direct positive effect of self−efficacy on behaviour was also confirmed.
*$p < .05$, **$p < .01$, ***$p < .001$

5 Discussion

Understanding how individuals sort waste in public spaces is crucial for supporting effective recycling practices and policies, as people spend most of their time outside the home. In the present study, we surveyed students and staff at the University of Florence to investigate self-reported recycling behaviour and the psychological and contextual factors influencing it. Identifying these factors in a university setting can inform both the design of spaces and systems and the development of interventions to promote recycling.

By applying the Fogg Behavioural Model (FBM; Fogg 2009), we designed questions examining key categories of variables: barriers to ability, prompts, and motivation. Each identified barrier was paired with a corresponding solution, which was then presented to participants. This approach enabled a direct link between reported barriers and potential interventions, laying the groundwork for future field testing. Our qualitative analysis revealed that employees reported more barriers and proposed more solutions than students, particularly in open-response sections, highlighting the value of directly incorporating user perspectives into decision-making processes. All barriers except one (Bar7: "The people around me do not think that recycling is important") were negatively associated with recycling behaviour. The strongest barriers related to two prompts (Bar2 and Bar3) and one ability factor (Bar5), while motivation-related barriers showed weaker or no associations. These findings suggest that environmental and physical constraints, such as limited access to recycling areas and low visibility of bins, can hinder sorting behaviour even among motivated individuals. Moreover, these

three barriers were strongly intercorrelated, suggesting they reflect a common underlying issue of bin visibility and accessibility. Interventions targeting one are therefore likely to reduce the others simultaneously, offering an efficient leverage point for behaviour change.

To examine how contextual and psychological factors jointly predict recycling behaviour, we conducted a linear regression analysis. Our three-predictor model (barriers, self-efficacy, and personal norms) explained just over 20% of the variance in reported recycling behaviour, considered an acceptable level in behavioural and applied social science research (Cohen 1988; Prentice & Miller 1992; Ozili 2023). Recycling behaviour was positively correlated with self-efficacy, consistent with prior work linking internal environmental locus of control to pro-environmental behaviour (Allen & Ferrand 1999; van Valkengoed et al. 2024), and with personal norms, supporting the Value-Belief-Norm (VBN) theory, which links values, beliefs, and norms to pro-environmental actions (Schwartz 1977; Geiger et al. 2019; Park & Ha 2014). Mediation analysis further revealed that higher self-efficacy predicted fewer perceived barriers, which partially mediated its positive association with recycling behaviour. However, self-efficacy also exerted a direct effect, suggesting that personal agency encourages recycling even in the presence of contextual obstacles. Taken together, these findings highlight the need for a dual approach: strategies that enhance motivation and self-efficacy should be paired with structural improvements to the environment.

Using the FBM framework proved useful in revealing patterns among barriers that would not have been apparent without a structured theoretical lens. The mediation analysis showed that self-efficacy predicted fewer perceived barriers, suggesting that psychological and contextual factors interact rather than operate independently, consistent with the FBM's premise that motivation, ability, and prompts must converge for behaviour to occur. Individuals with lower self-efficacy may be more sensitive to physical barriers such as bin inaccessibility or poor signage, while higher self-efficacy individuals may compensate for contextual shortcomings. This has practical implications: interventions addressing only structural barriers without attending to motivational factors (or vice versa) may produce limited gains. Future research could also test FBM against the TPB, which dominates the recycling literature but does not explicitly account for situational prompts as a necessary condition for behaviour, to assess their relative predictive validity and practical utility for intervention design.

Since self-efficacy emerged as the most influential psychological predictor of reported recycling behaviour, interventions targeting both individual and collective efficacy could be valuable. Providing feedback can enhance self-efficacy (Abrahamse & Steg 2013) and facilitate spillover from simple to more complex pro-environmental behaviours (Lauren et al. 2016). However, interventions aimed solely at boosting individual efficacy have shown mixed results, often failing to produce lasting behaviour change (Hornsey et al. 2021). Collective efficacy—though related—may be more effective in group-based contexts such as universities. Evidence suggests that strengthening self- and collective efficacy simultaneously can enhance pro-environmental intentions (Jugert et al. 2016). While recycling is typically an individual activity, the fact that it occurs in shared public spaces indicates that fostering collective efficacy could be a promising strategy in this context.

In the context of the University of Florence, two issues emerged as significant barriers to recycling: limited visibility of recycling stations (Bar2) and lack of convenience (Bar5). These structural challenges, stemming from suboptimal space planning, can lead even environmentally conscious individuals to struggle with waste sorting due to practical constraints. Addressing these barriers requires both immediate interventions and long-term policy integrations in urban and space planning when designing new areas. Research shows that proximity to recycling points increases the likelihood of recycling (Simmons & Widmar 1990). For example, placing compost bins closer to living spaces in multi-family residences led to a 130% increase in recycling rates and a 70% increase in composting rates (DiGiacomo et al. 2018). Interventions could include increasing the number of bins in high-traffic areas, improving signage and visibility, ensuring intuitive placement where waste is generated, and using consistent colour coding and labelling to reduce confusion.

Understanding the relationship between barriers and recycling behaviour is essential for designing targeted interventions and informing policy. A key feature of our study was engaging directly with the population experiencing these barriers, enabling interventions to be tailored to real-world needs. While regulations set minimum requirements, public bodies and waste management providers retain considerable flexibility in system design — and it is precisely at this level that behavioural evidence can have the greatest impact. Universities should integrate user input into planning to ensure infrastructure aligns with actual needs, and standardised guidelines for bin placement and labelling can improve system cohesion and efficiency across institutions. More broadly, the survey tool developed here can be readily adapted for use across different public settings, enabling comparisons across contexts and time points, including pre- and post-intervention assessments, and providing policymakers with a scalable instrument for monitoring behavioural drivers of recycling. Designing collection processes with user convenience in mind, and giving end-users agency in these processes, supports long-term engagement and strengthens the case for embedding behavioural science into sustainability policy at both institutional and municipal levels.

The ongoing collaboration with the University of Florence's Green Office and the waste management provider offers an opportunity to translate these findings into practice and to contribute evidence that extends beyond the present study (Falsini et al., 2019, 2023). By embedding behavioural insights into decisions about infrastructure, training, and communication, this partnership demonstrates how university-based research can inform institutional sustainability policy and feed into the broader governance of urban waste management. Initiatives currently underway — including redistribution of collection points, installation of additional bins, and promotion of reusable alternatives — provide a real-world testing ground for the barriers and solutions identified here, and their outcomes will inform future policy recommendations at both campus and municipal levels. Such an approach offers a replicable model for other universities and public institutions seeking to bridge the gap between aspirational sustainability goals and operational change, and illustrates how academic research can contribute directly to the evidence base that policymakers need to design effective, context-sensitive recycling systems.

While our findings provide valuable insights into recycling behaviour in public university spaces, several limitations should be acknowledged. First, the study is correlational, so causal relationships between barriers, psychological factors, and recycling behaviour cannot be established. Second, the research was conducted at a single university using a convenience sample, which limits the generalisability of the results to other institutions or populations. Third, the role of collective efficacy in group-based or public contexts warrants further investigation, as our study focused primarily on self-efficacy. Future research could test interventions targeting both individual and collective efficacy, employ longitudinal designs to explore causal pathways between psychological factors, perceived barriers, and recycling behaviour, and use structural equation modelling (SEM) to examine more complex relationships among the most influential predictors identified in the present study. Finally, while our analyses including the BIDR scale suggest minimal independent effects of social desirability on reported recycling behaviour, future studies would benefit from combining self-reports with observational or objective measures to more accurately capture actual behaviour.

6 Conclusion

In conclusion, this study highlights the significant role of both psychological factors, such as self-efficacy and personal norms, and contextual barriers in influencing recycling behaviour in public spaces. By engaging directly with the university population and identifying key barriers, we have outlined targeted interventions that can improve recycling practices on campus. Our findings emphasise the importance of addressing physical barriers like the visibility and convenience of recycling stations, while also enhancing individual and collective self-efficacy to encourage pro-environmental behaviour. Despite some limitations, the results provide a strong foundation for future research, particularly in testing interventions in real-world settings and exploring the role of collective efficacy in group-based contexts. Ultimately, the study underscores the need for a holistic approach in designing interventions that integrate both motivational and structural factors to promote sustainable behaviours.

Appendix A

Survey questions

Measured on a 5-point Likert scale

Contextual barriers, recycling knowledge (Information), trust in the recycling process, human-nature beliefs (Human nature), BIDR-16 Impression Management (IM) subscale (adapted from 6 to 5 points): 1 = Completely disagree, 5 = Completely agree
Personal norms: 1 = Strongly disagree, 5 = Strongly agree
Self-reported sorting behaviour (Behaviour): 1 = Never, 5 = Always

Measured on a 7-point Likert scale

Self-efficacy and collective efficacy: 1 = Strongly disagree, 7 = Strongly agree
Risk Perception of Climate Change (RPCC): end points vary by item (e.g., 1 = Not serious at all, 7 = Very serious)

Original item	Scale	Legend
	Barriers: this set of 9 items investigates possible barriers individuals face when sorting in the university. The items are formulated taking into consideration Fogg's Behaviour model, where actions need Motivation, Ability and prompts to be performed	
The labels on the containers are not clear		Bar1
I do not know where the recycling bins are, so I use the first bin I can find		Bar2
The containers do not stand out enough		Bar3
I lack the information to recycle correctly, e.g. what goes where		Bar4
The recycling bins are too far from my classroom/office		Bar5
The recycling bins I need for my typical waste are not available		Bar6
The people around me do not think that recycling is important		Bar7
I think recycling in public areas (e.g. university, office etc.) is not my responsibility		Bar8
I lack the motivation to recycle in the university/public places		Bar9

Original item	Scale	Legend
	These items investigate possible facilitators that support sorting in the University, from having the know-how information to trusting the system to personal norms regarding recycling	
I am well informed about environmental issues and problems		Info1
I have enough information to sort my waste properly, such as how and where to dispose of it		Info2
I have no idea what happens to waste after it has been collected		Info3
To what extent do you feel confident that the waste that you have sorted is actually recycled?		Trust
I feel morally obliged to recycle		Pnorm1
I would feel guilty if I did not recycle		Pnorm2
I would be a better person if I would recycle		Pnorm3
	Self-efficacy (SE) and Collective efficacy (CE) in environmental actions. This scale, adapted from Tam (2014), measures individuals' perceived self-efficacy and collective efficacy in humans' ability to recycle effectively	
My actions in recycling can have a meaningful impact		SE1
I feel confident in my ability to recycle		SE2
I can be effective in protecting the environment through recycling		SE3
My recycling actions can help resolve the environmental crisis		SE4

Original item	Scale	Legend
People's actions in recycling can have a meaningful impact		CE1
I feel confident in human beings' ability to recycle		CE2
We as human beings can be effective in protecting nature through recycling		CE3
Human beings' recycling actions can help resolve the environmental crisis		CE4
	Risk Perception of Climate Change (RPCC; van der Linden 2015). The scale aims to measure the risk perception of climate change through 8 items	
How concerned are you about climate change?		RP1
In your judgment, how likely are you, sometime during your life, to experience serious threats to your health or overall well-being, as a result of climate change?		RP2
In your judgment, how likely do you think it is that climate change will have very harmful, long-term impacts on our society?		RP3
How serious of a threat do you think that climate change is to the natural environment?		RP4
How serious would you rate current impacts of climate change around the world?		RP5
How serious of a threat do you believe that climate change is to you personally?		RP6
How serious do you estimate the effects of climate change for Italy?		RP7

Original item	Scale	Legend
How often do you worry about the potentially negative consequences of climate change?		RP8
	Social desirability was measured using the Impression Management (IM) subscale of the Short version of the Balanced Inventory of Desirable Responding (BIDR-16; Bobbio & Manganelli 2011; Paulhus, 1991), which assesses the tendency to provide socially desirable responses	
I sometimes tell lies, if I have to		BIDR1
There have been occasions when I have taken advantage of someone		BIDR2
I always obey laws, even if I'm unlikely to get caught		BIDR3
I have said something bad about a friend behind their back		BIDR4
I have never dropped litter on the street		BIDR5
I have done things that I don't tell other people about		BIDR6
I have taken sick leave from work or school even though I wasn't really sick		BIDR7
I have some pretty awful habits		BIDR8
	Human nature. These two items assess agreement on whether humans should exploit or care for the planet	
Humans have the right to use all resources on earth as they please		H1
Humankind must look after the planet		H2

Original item	Scale	Legend
How often do you usually recycle your waste when you are at University?	Recycling behaviour. Self-reported measure of how often individuals recycle on university premises	BEH
	Demographic questions	
Please write your age in numbers		Age
How would you describe your political orientation?		Polit
Please select the option that corresponds most to your current position at the University: Student—Research assistant—Academic staff—Administrative/ support staff (PTA)—Linguistic collaborators		Occupation

Appendix B

Hierarchical regression models 1 and 3

Hierarchical regression models examining the robustness of predictors of recycling behaviour. Models 1–3 include barriers, psychological factors, social desirability (BIDR), and demographic controls. The table presents model fit statistics and estimated coefficients for models not shown in the main text .

Contextual barriers only - Model 1

Model fit measures					
Model	R	R^2			Adjusted R^2
1	0.477	0.227			0.207
Model Coefficients—BEH					
Predictor	Estimate	SE	t	p	Standard Estimate
Intercept[a]	5.18259	0.1500	34.545	< 0.001	
Bar1	0.02953	0.0291	1.014	0.311	0.0455
Bar2	−0.16766	0.0367	−4.564	< 0.001	−0.2493
Bar3	−0.06674	0.0395	−1.692	0.091	−0.0952
Bar4	−0.00952	0.0307	−0.310	0.757	−0.0139
Bar5	−0.13794	0.0364	−3.791	< 0.001	−0.1928
Bar6	−0.01756	0.0319	−0.551	0.582	−0.0259
Bar7	0.06379	0.0280	2.281	0.023	0.0967
Bar8	−0.01740	0.0676	−0.257	0.797	−0.0129
Bar9	−0.08563	0.0500	−1.713	0.087	−0.0878
Gender:					
2 – 1	−0.11021	0.0801	−1.376	0.169	−0.1248
3 – 1	−0.13951	0.3661	−0.381	0.703	−0.1579
4 – 1	−0.10797	0.2143	−0.504	0.615	−0.1222

[a]Represents the reference level.

Barriers, BIDR, gender - Model 3

Model fit measures			
Model	R	R^2	Adjusted R^2
3	0.482	0.232	0.210

Model coefficient—BEH

Predictor	Estimate	SE	t	p	Standard estimate
Intercept[a]	4.83578	0.2601	18.591	< 0.001	
Bar1	0.02873	0.0291	0.988	0.323	0.04424
Bar2	−0.16270	0.0368	−4.421	< 0.001	−0.24196
Bar3	−0.06257	0.0395	−1.585	0.114	−0.08924
Bar4	−0.00338	0.0309	−0.109	0.913	−0.00492
Bar5	−0.13538	0.0364	−3.724	< 0.001	−0.18924
Bar6	−0.02120	0.0319	−0.665	0.507	−0.03127
Bar7	0.06470	0.0279	2.317	0.021	0.09807
Bar8	−0.02839	0.0678	−0.419	0.676	−0.02106
Bar9	−0.06942	0.0509	−1.365	0.173	−0.07114
BIDR Mean	0.08516	0.0522	1.631	0.104	0.07119
Gender:					
2 – 1	−0.12212	0.0803	−1.521	0.129	−0.13824
3 – 1	−0.16655	0.3658	−0.455	0.649	−0.18852
4 – 1	−0.10095	0.2140	−0.472	0.637	−0.11427

[a]Represents the reference level.

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Declarations

Conflict of Interest The authors declare that they have no competing interests in the content of this article. All authors certify that they have no affiliations or any involvement, of any nature, in the subject matter or materials discussed in this manuscript.

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