PACKAGING WASTE MEASUREMENT & REDUCTION PROPOSAL

Prepared for:
LSE Catering, LSE Global School of Sustainability, Climate Food (In)security Lab at the Grantham Research Institute

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1. Overview

Overview

This proposal is for the LSE Global School of Sustainability, Climate Food (In)security Lab and LSE Catering Services on measurement and reduction strategies for packaging waste at LSE. The document addresses measurement and reduction across multiple phases of strategy implementation: Phase 1 (Supplier Packaging Waste), Phase 2 (Customer-Facing Packaging Waste), Phase 3 (Post-consumer Packaging Waste), and Phase 4 (Disposal and End-of-Life), as outlined by GSoS. Each phase considers economic feasibility and uses case studies and literature to ground the recommended interventions. LSE Catering operates across three streams — Retail (cafés and restaurants), Hospitality (catering at business meetings and events) and Halls (residence dining). While all three are considered, our primary focus is Retail, which offers the greatest scope for impact.

In this report, we examine two crucial challenges faced by GSoS at LSE: the lack of data on packaging waste and the absence of sustainable waste-disposal processes. We have provided measurement suggestions, potential analysis and a pilot scheme for reduction to be implemented.

Problem Statement

The LSE Global School of Sustainability wants to reduce packaging waste and cross-contamination to improve recycling quality and increase LSE's institutional reputation. LSE currently operates a four-stream bin system on campus (dry mixed recycling, paper recycling, food waste and general waste) with additional specialist streams for items such as single-use hot drinks cups and batteries (London School of Economics and Political Science, 2026). Despite these facilities, contamination and misplacement rates remain high, motivating the measurement and reduction strategies outlined in this proposal.

2. Data Collection Methods

Measurement – Phase 1 & 2

Supplier delivery, kitchen preparation, and packaging are the focus of data collection in Phase 1. When LSE orders cups, boxes, etc. from the supplier, the quantities and product type must be logged for legal purposes. We propose auditing LSE orders to identify the quantity and recyclability of packaging.

The logging of this data will allow LSE to quantify the amount of packaging produced from each product, and since the types of products that LSE orders are known, the composition of each product will be easily identified. This can be done through the logging of each product from LSE's main supplier, TUCO, which is a consortium of suppliers provided to LSE to choose from for different packaging purposes (ie. coffee cups, sandwich packaging).

In addition to order-based logging, we can apply a behavioural perspective through a direct observation of how packaging is actually used and discarded in real time, which can surface issues that order data alone cannot. Walt Disney's '30-Step Rule' is a customer-observation technique in which staff are trained to scan the 30 feet of space around them for anything out of place, including overflowing bins or misused packaging, and to address it immediately (Gardner, 2024). Applied to LSE's catering outlets, a similar walk-through observation protocol during Phase 1 and 2 audits could help identify points where packaging is being discarded, contaminated, or misused before it even reaches a bin.

Variable	Unit	Proxy for
Quantity of each packaging item ordered	Units per order	Total volume of each packaging type entering the LSE waste stream
Mass of packaging per order line	kg	How much packaging is used relative to the product it contains
Recyclable vs non-recyclable packaging mass	kg per material type	The proportion of incoming packaging that can be recycled
Supplier identity	Supplier name	Source of packaging; enables comparison of sustainability performance across suppliers
Material composition per product	Material type (e.g. PET, card, film)	Whether a given packaging type can enter dry mixed recycling or a specialist stream

Figure 2.1: Phase 1 & 2 measurement variables, units and proxies

Measurement – Phase 3

Customer-facing packaging is the focus of data collection in Phase 3, building on the same purchase-logging principle used in the earlier phases. When students buy items from LSE's restaurants and cafés, those purchases are already logged at the till; for free-grab items like napkins and sachets, which the till doesn't record, usage can instead be counted from stock records (opening stock + purchases closing stock). Together, this allows LSE to identify how much of each packaging product is generated on campus and to track its composition — plastics, cardboard, paper and so on — from which the quantity of packaging waste per product can be calculated. This matters because items with mixed compositions, such as sandwich cartons and coffee cups, are difficult to recycle effectively.

Bin-monitoring observations at the University of San Francisco found that the majority of campus waste is derived from single-use items such as coffee cups and food-to-go containers (Crane, 2025). This supports the Phase 3 measurement focus on customer-facing packaging, as single-use items purchased directly by consumers are likely to account for the largest share of LSE's packaging waste stream and should be prioritised when logging purchase data.

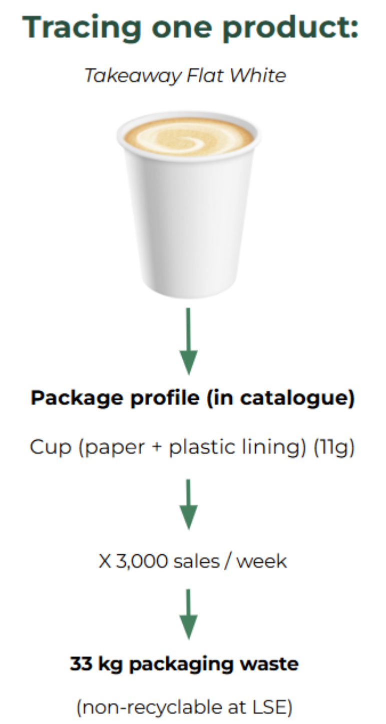

Figure 2.2: Product Tracking Example

Variable	Unit	Proxy for
Number of each packaging item sold	Units per transaction	Volume of packaging actively circulating on campus and likely entering the waste stream
Product type at point of sale	Category (e.g. hot drink, sandwich, snack)	Composition of packaging waste by material type available to consumers
Sales by outlet location	Units per café or restaurant	Spatial distribution of packaging waste generation across LSE
Reusable vs disposable cup ratio	Proportion	Consumer uptake of reusable alternatives; baseline for evaluating behaviour change interventions
Mixed-composition packaging sold	Units (e.g. coffee cups, sandwich packets)	Items difficult to recycle due to multiple bonded materials; highest-risk products for contamination

Figure 2.3: Phase 3 measurement variables, units and proxies

Measurement – Phase 4

Post-consumer packaging waste is the focus of data collection in Phase 4. This refers to the quantity and quality of waste disposal, whether that be through recycling or otherwise. Previous methods have included waste audits, such as for ‘The Great Plastic Divestment’ (Beleva et al., 2021), a student-led investigation into LSE’s plastic waste in 2021. However, this has not been replicated or reported on since. We suggest that this strategy be re-implemented to ensure that research is up-to-date and relevant. This can be through continued waste audits, whether by external contractors such as Biffa or by internal faculty, such as staff or students. Weighing bags and visual inspections can help us classify data and pinpoint issues.

A methodology developed for solid waste audits highlights that spatial and temporal variation in waste generation can cause estimated waste quantities to differ substantially from documented values, and proposes approaches for extrapolation and validation to address this (Felder et al., 2001). This is directly relevant to LSE’s bin audits: a single audit at a single time and location may not be representative of waste generation across campus or across the academic year, and any extrapolation from audit samples to campus-wide totals should account for this variation.

Variable	**Unit**	**Proxy for**
Quantity of each item found in each bin type	Count per bin audit	How often each product is sorted correctly versus incorrectly
Bin location	Building / floor	Spatial variation in disposal behaviour; identifies problem areas for targeted intervention
Visible contamination in bin	Binary or ordinal score (none / minor / severe)	How likely a misplaced item is to spoil the surrounding recyclable material
Weight of waste per stream per bin bag	kg	Total mass of waste by stream; enables extrapolation to campus-wide tonnage estimates
End-of-life pathway per stream	Categorical (recycled / composted / EfW / landfill)	How sustainably each waste stream is processed once it leaves campus
Audit date and term	Date / academic term	Temporal variation in waste generation; whether contamination rates differ by season

Figure 2.4: Phase 4 measurement variables, units and proxies

A suggested analysis for these audits can be conducted using 'Waste Composition Analysis', currently being implemented by Imperial College London. A reproducible diagram has been attached below for reference.

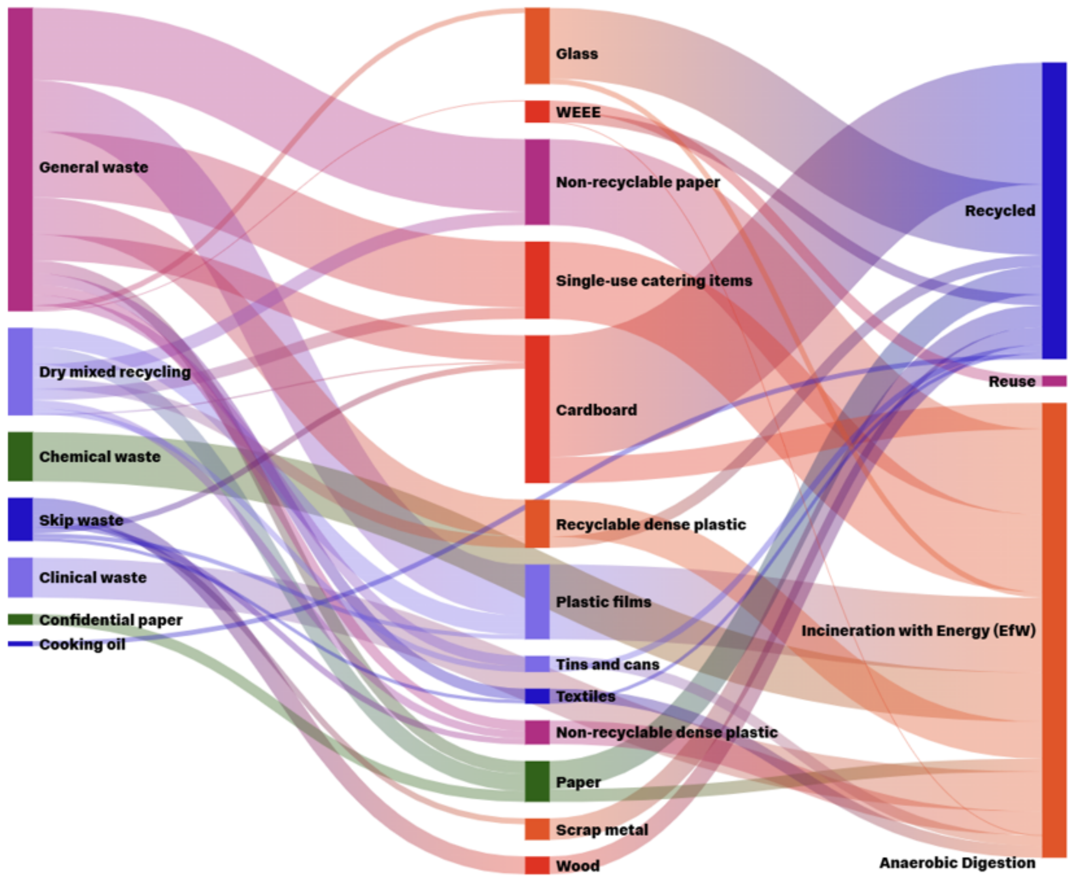

Figure 2.5: Waste Composition Analysis – Sankey diagram of waste streams, material categories and end destinations (Imperial College London, 2026).

At Imperial (Imperial College London, 2026):

- Food waste is taken to anaerobic digesters where it is used to generate green energy and a nutrient-rich digestate, which is used as an agricultural fertiliser.
- Dry recyclables are taken to a London recovery facility where materials are segregated, baled, and sent on to reprocessors for recycling.
- General waste is taken to South East London Combined Heat and Power, where it's incinerated with energy recovery.

Longer-term solutions can involve using technology, such as scanners or reverse-recycling machines, to track waste disposal. Reverse vending machines (RVMs) accept items such as cans, glass, and plastic and can incorporate image processing via a camera to identify material type, though high implementation and maintenance costs mean they remain uncommon (Mariya et al., 2020). An implementation using microcontrollers and sensors in a standard recycling bin achieved a 97% success rate with an average operating time of 35 seconds and weight accuracy to within ± 5.5 grams (Tomari et al., 2017), demonstrating that automated, sensor-based logging of disposal data is technically feasible and could supplement manual bin audits if cost barriers are addressed. This is detailed further in the reduction strategies.

A separate study measuring the flow of post-consumer plastic packaging through Germany's waste system provides a model for tracking packaging from entry to end-of-life across a large system (Picuno et al., 2021); the same flow-based approach could be extrapolated to model packaging flows through LSE's catering and waste operations, complementing the bin audit data with a system-level view of where packaging enters, circulates, and exits.

Quantitative Analysis

The lack of available data indicates that we can only hypothesise what we could potentially do with the data. Whether this can truly be achieved depends on the difficulty of collection and the reliability of data. We have attempted to minimise the data collection required to improve feasibility for the university, using current data to its full extent.

All of the proposed analyses have been simplified, condensing into just three indices to measure each product's sustainability.

Phase 1 & 2

Phases 1 and 2 can largely be categorised as the choice of inputs that the LSE purchases for its food packaging. Its measurement is based on an audit of the packaging that LSE's caterers order in. Every item of packaging entering LSE's catering operation (cups, containers, wrapping, cutlery, sachets, etc.) would arrive through a logged supplier order, which records the quantity, product type, and material composition of each item for delivery and legal purposes. This existing order data gives LSE a direct, ready-made record of the packaging entering the system, without requiring any new physical waste sampling.

Auditing supplier orders provides a reliable proxy for the volume and composition of packaging waste generated, while also identifying exactly where that packaging originates, including which supplier, product line, and material type.

To convert order data into actionable insights, we propose a single novel index that scores the sustainability of a product's packaging based on two factors: how recyclable the packaging material is and how much packaging is used relative to the product itself.

Packaging Sustainability Index (PSI)

We define the **Packaging Sustainability Index (PSI)** for a given product or supplier as:

$$\boxed{\mathrm{PSI} = \frac{R + (1 - E)}{2}} \tag{2.6}$$

where:

- $R = \dfrac{m_{\text{recyclable}}}{m_{\text{recyclable}} + m_{\text{non-recyclable}}}$ is the **recyclability ratio**: the proportion of packaging mass that is recyclable.
- $E = \dfrac{m_{\text{packaging}}}{m_{\text{packaging}} + m_{\text{product}}}$ is the **packaging intensity ratio**: the proportion of total delivered mass made up of packaging rather than product.

This formula assumes the recyclability ratio and packaging intensity ratio are equally important. Should it be determined that this is not the case, factors/weightings can be added to each ratio, transforming it to:

PSI ranges from 0 (worst case: entirely non-recyclable packaging that forms a large proportion of total delivered mass) to 1 (best case: fully recyclable packaging that is negligible relative to product mass).

Both R and E can be read directly from the supplier order audit: the mass of packaging and product per order is already recorded for delivery purposes, and the material composition of each packaging type is known from the product specification. This means PSI can be calculated for every supplier line item with no/minimal additional data collection beyond reviewing existing order records.

$$\boxed{\mathrm{PSI} = w_1 \cdot R + w_2 \cdot (1 - E)} \tag{2.7}$$

where $w_1 + w_2 = 1$. Setting $w_1 = w_2 = 0.5$ recovers the unweighted formula above.

Phase 3 & 4

While Phases 1 and 2 assess packaging at the point it enters LSE (inputs), Phases 3 and 4 assess what happens to that packaging once it becomes waste (outputs). This requires a different metric, since the question is no longer about the inherent recyclability of a material but about how reliably it is actually sorted, whether it contaminates other waste streams, and how sustainably it is processed once disposed of.

Disposal Sustainability Index (DSI)

$$\boxed{\text{DSI} = w_1 \cdot C + w_2 \cdot P - w_3 \cdot (1 - C) \cdot P_{\text{contam|wrong bin}}} \tag{2.8}$$

- $C = \frac{q_{\text{correct}}}{q_{\text{total}}}$: **correct sorting rate**: the proportion of the product's total quantity found in the correct bin (recycling or general waste), drawn directly from bin audit data. Equivalently, $(1 - C)$ is the probability a unit of this product ends up in the wrong bin.
- P: **processing sustainability score**: a 0–1 score reflecting the end-of-life pathway of correctly-sorted material, based on the waste hierarchy (Figure 2.9).
- $(1 - C) \cdot P_{\text{contam|wrong bin}}$: **Contamination penalty**: how often an item ends up in the wrong bin, weighted by how likely it is to spoil other recyclables when it does (a leaking cup is worse than a dry wrapper). Estimated from audit observations of visible contamination among misplaced items.

The weights w_1, w_2 and w_3 determine how much each component contributes to the overall score, and can be adjusted to reflect LSE's priorities. We suggest $w_1 = 0.4$, $w_2 = 0.4$ and $w_3 = 0.2$ as a starting point: correct sorting and processing quality are weighted equally as the two factors most directly within LSE's control, while the contamination penalty is weighted lower since it acts as a secondary adjustment on top of the sorting rate rather than an independent driver of the score. DSI is clamped to $[0, 1]$ to keep it comparable across products.

Figure 2.9 assigns a score P to each possible end-of-life pathway, reflecting the waste hierarchy: pathways that keep material in use longest and require the least energy and processing score highest, while landfill, the least desirable outcome, scores zero. On-campus reuse or closed-loop recycling scores highest as it avoids transport and reprocessing entirely, while landfill scores zero as it recovers neither material nor energy. Other pathways sit in between to reflect relative sustainability. Each product's P value corresponds to the pathway its correctly-sorted waste is most likely to follow.

End-of-life pathway	P
On-campus reuse / closed-loop recycling	1.00
Off-campus recycling (UK reprocessing)	0.75
Anaerobic digestion / composting	0.60
Energy from Waste (incineration, energy recovery)	0.30
Landfill	0.00

Figure 2.9: Processing sustainability scores by end-of-life pathway

Overall Product Sustainability Score (OPSS)

For each product, an overall score combines its input-side performance (PSI, Phase 1 & 2) with its output-side performance (DSI, Phase 3 & 4):

$$\boxed{\text{OPSS} = \frac{\text{PSI} + \text{DSI}}{2}} \tag{2.10}$$

This gives LSE a single comparable figure per product reflecting both how sustainably it arrives on campus and how sustainably it leaves. Products scoring lowest on OPSS represent the clearest priorities for intervention, as they perform poorly on both the supply side (low recyclability, high-packaging-intensity materials) and the disposal side (frequently misplaced, often non-recyclable even when sorted correctly). Products scoring highly are already well served by existing infrastructure and represent lower-priority targets for new intervention.

Indices can also be compared across locations and branches (such as cafes and halls of residence) at the LSE, providing insight into the most unsustainable areas and which parameter each branch falls behind on.

3. Reduction Strategies

This chapter outlines the practical strategies LSE can adopt to reduce packaging waste across its catering operations. The approach prioritises measures that are low-cost, immediately implementable and evidence-based, while also identifying longer-term structural changes that would have greater impact if properly resourced. Across all phases, the goal is the same: to reduce the volume of packaging waste generated, increase the proportion that is correctly sorted, and reduce contamination so that what is placed in recycling bins can actually be recycled.

Phase 1 & 2

To reduce waste on the supplier side, LSE can switch to more reusable items, replacing single-use items. One recommendation for this is Notpla (Notpla, 2026): a London-based startup designing fully compostable packaging. That is already being used by Imperial (Imperial College London, 2025). At the kitchen-preparation stage, we suggest removing single-use cutlery entirely and switching to providing metal cutlery instead and then washing and reusing them instead of providing a new single-use spoon/fork/knife every time someone orders something from the restaurants and cafes. Higher education institutions face competing priorities when evaluating suppliers, making it essential to set clear sustainable procurement criteria to drive meaningful reductions in single-use packaging at source (Prajapati, 2024).

Evaluation

Replacing single-use items may reduce restaurant sales due to the inconvenience of takeout orders. Students may not have their own cutlery and would not be able to take the metal cutlery from the restaurants and cafes outside of the establishments, hence disincentivising restaurant purchases that apply these changes.

Phase 3 & 4

- Stickers may be added to all takeout packaging to indicate which bin each part of a package should be disposed of. This reduces the amount of incorrect waste disposal in LSE, as it would be far easier to identify where to place the respective packaging waste.
- In Halls (residence dining), crockery, cutlery and mugs are already reusable, so the main remaining single-use item is sachets. Phasing these out in favour of bulk dispensers for sauces, jam and honey removes this packaging at source, which is the main reduction opportunity in this stream.

Contamination reduction measures must also be implemented to ensure the recyclability of waste packaging is not inhibited.

- One way to achieve this is by charging people for unfinished meals. This incentivises customers to finish their meals, and therefore, less contaminated packaging will be disposed of. For instance, this policy is implemented at Yo Sushi! (YO! Sushi, 2026).
- Create a new bin dedicated only to disposing of packaging which can certainly be recycled. To prevent the recyclable waste from being contaminated, the packaging thrown away must have its QR code scanned to ensure that all the waste is truly recyclable, and this will also provide more data, which can be logged into the LSE system to measure their sustainability, and will also outline which products are most and least recycled. This would provide a clearer picture of which product to focus more strongly on for waste reduction. For example, if coffee cups are the least recycled waste packaging product, LSE can consider switching to a different supplier to improve their recyclability.
- Colour-coding packaging by material type has also been shown to improve sorting accuracy, with hyperspectral imaging techniques demonstrating that visual colour classification can optimise the separation of post-consumer plastic packaging at the point of processing (Cucuzza et al., 2023); applying consistent colour-coding to LSE's packaging could extend this logic to the point of disposal, making it easier for consumers to identify the correct bin. Research on compostable packaging further finds that clear disposal instructions and physical intervention at the point of use are needed to ensure appropriate compostable items recycling (Buckland et al., 2025), a finding directly relevant to LSE, given the high misplacement rates observed for compostable stirrers and cups in the bin audit data.
- From a behavioural perspective, LSE can provide simple human-eye nudging to promote recycling by simply implementing more signs and clear instructions on how to recycle different types of waste and reduce contamination by separating the food/drink from the packaging it was contained within. Research conducted across the University College London (UCL) campus found that combining human-eye visual nudges with existing sorting instructions reduced mixed-recycling sorting errors by 7 percentage points, though visual nudges alone increased errors by 4.5 percentage points, suggesting that clear written guidance must accompany any visual intervention (Lotti et al., 2023). A similar approach could be applied within LSE Catering's Hospitality stream: the catering provided at business meetings and events, where most items (cups, cutlery and plates) are already reusable rather than single-use. An identified issue here, though, is that these reusable items, particularly cups, are often binned after meetings instead of being left for collection and washing. To address this, a sign reading "Cups, cutlery & plates → leave here. Reusable, not for the bin," paired with a human-eye image, could be placed beside a designated return tray on the refreshments table. This applies the same principle: the written instruction is paired with the visual cue, since Lotti et al. (2023) found that visual nudges alone increased errors, whereas combining them with clear written guidance reduced incorrect disposal.

- Bin saliency (features that make a bin stand out from its surroundings) is also important: strategic bin placement on common walking paths, explicit symbols, minimal text on signage, and lid shapes that guide disposal behaviour have all been shown to increase correct waste bin use (Högberg and Sörqvist, 2026). Placing recycling bins closer to the point of consumption, such as inside eating areas rather than only in hallways, has been found to more than double recycling rates compared to simply increasing the number of bins in common areas (O'Connor et al., 2010).
- UNSW Sydney estimates it disposes of approximately 2.5 million single-use packaging items every year and has launched a "Choose to Reuse" movement encouraging students to bring their own cups and containers, with partner retailers offering discounts for doing so (University of New South Wales, 2026). A comparable reuse incentive scheme at LSE could directly reduce the volume of single-use packaging entering the waste stream.

Evaluation

The waste contamination reduction strategies have several drawbacks for each recommendation:

- **Adding Stickers to Packaging:** Adding stickers to packaging may increase the labour required from each establishment, therefore increasing their costs. Consequently, adding stickers may be time-consuming, so if this is done when food is served at the establishments, queues may form and further deter customers.
- **Unfinished meal charges:** It is difficult to monitor consistently and fairly. Customers may see the charge as punitive. Some customers may be unable to finish their meals due to illness, dietary needs, or portion sizes. It may encourage people to overeat or dispose of unfinished food elsewhere. It addresses customer behaviour rather than the causes of waste, such as oversized portions. It may have little effect on packaging quantities because the packaging is still issued.
- **QR-code recycling bins:** A scan confirms the packaging design, but not whether the item is empty or clean. Food-contaminated packaging could still be scanned and placed in the bin. Customers may avoid using the bin if scanning takes too long. The system would require specialised bins, software, maintenance and data management. QR codes may become damaged, covered or difficult to scan. Packaging bought outside the LSE may not be recognised. People could scan one item and place several incorrect items inside. The environmental and financial benefits may not justify the cost across the whole campus.
- **Visual nudges (Human-eye images):** Human-eye images alone do not explain how to recycle. The effect it should have may weaken as users become familiar with the signs. Lotti et al. (2023) found that once the intervention was removed, sorting errors returned to baseline levels. This also suggests that the eye nudge produces temporary rather than sustained behaviour change, and that it must be maintained continuously to remain effective. Generic recycling symbols may still leave users uncertain. The strategy will not solve problems caused by packaging that is technically difficult to recycle. Too much information may make signs harder to understand.
- **Continuous waste monitoring:** Only the visible top layer is inspected. Contamination lower in the bag may be missed. Different staff may assess contamination differently. Large visible items may appear more significant than numerous smaller contaminants. The sticker system alone does not measure contamination accurately by weight. Staff require simple training and consistent assessment criteria.

Information-related Measures

A systematic review of the drivers and barriers to consumers' plastic packaging waste avoidance and recycling finds that convenience, habit, and a lack of clear information are the primary barriers to behaviour change, while financial incentives, visible infrastructure, and social norms are the most effective enablers (Jacobsen et al., 2022). However, Allison et al. (2022) illustrated that without proper diagnosis of current behaviours, information campaigns may be ineffective and even backfire. This creates the need to collect LSE-specific data prior to employing potential information-related measures.

Short-term Measures

In the short term, LSE should collect institution-specific evidence to understand why recyclable packaging is being placed in general waste and why reusable schemes have low uptake. Surveys, focus groups, and a gamified waste-sorting experiment in collaboration with the LSE Behavioural Lab could be used to identify common misunderstandings, behavioural barriers, and awareness gaps. Based on these findings, LSE should improve the placement and signposting of specialised bins, particularly for packaging types that are frequently misclassified. It should also increase awareness of existing reusable-cup discounts and combine simple recycling information with visual nudges, such as clear images and human eye prompts, to attract attention and make correct disposal easier (Lotti et al., 2023).

Long-term Measures

In the longer term, LSE should embed recycling and reuse guidance into the student experience rather than relying only on temporary campaigns. A sustainability induction module could be introduced during Freshers' Week to explain the campus waste system, reusable schemes and correct packaging disposal from the beginning of each student's time at LSE. This would combine the immediate benefits of signposting with longer-term institutional learning and use the existing Consent Education infrastructure for support. LSE could also use the campus as a living laboratory, with academics and students analysing the results, publishing the process and translating successful research findings into permanent operational changes.

Evaluation

Surveys and focus groups may be affected by self-report bias because participants may overstate how well they recycle. The timing of data collection is also important, as behaviour may vary during Freshers' Week, examination periods or holidays. It may also be difficult to prove that any improvement was caused by one specific intervention when several measures are introduced at the same time. LSE should therefore combine survey findings with physical bin audits, waste sorting data and reusable-scheme participation records, while comparing results before and after each intervention wherever possible.

Technological Measures

Short-term Technological Measures

In the short term, LSE could trial smart-bin technologies to improve monitoring and reduce contamination. Ultrasonic sensors could be fitted to general-waste and recycling bins to track fill levels, allowing collections to be scheduled only when needed and reducing unnecessary collection costs. A comparable pilot at a US public university projected annual savings of $89,519 across 28 bins, with 18% of collections found to be missed under the existing schedule (Sensoneo, 2024). LSE could also test barcode-scanning recycling bins that open only for approved bottles, cans and cartons. Because the bin remains locked until an eligible item is scanned, this system could reduce contamination and provide accurate data on the number and type of containers recycled. UNSW Sydney deployed exactly this model through the Charopy smart bin system, developed by an alumnus, specifically to tackle contamination in Return and Earn streams (UNSW Sydney, 2026).

Long-term Technological Measures

In the longer term, LSE could introduce a QR-code reusable-container scheme linked to student accounts or the LSE Food Club app. Customers would scan a reusable cup or food container when collecting it and return it within a fixed period, such as three days. Automated reminders could be sent before the return deadline, with a small fee charged only if the item is not returned. Washington State University implemented exactly this model through Topanga's ReusePass system across three residential dining centres, achieving a 97% container return rate and collectively diverting approximately 35,000 single-use containers across 14 universities as part of an Earth Day challenge (Washington State University, 2024). LSE could strengthen the scheme by charging for disposable containers while providing reusable alternatives free of charge when returned on time. Boston University adopted this approach, pairing a $2.50 fee for disposable containers with a loyalty scheme, and reduced disposable-container use by more than 83% (Boston University, 2023).

Evaluation

LSE should initially pilot these technologies in one or two busy cafes before expanding them across campus. The evaluation should compare installation and maintenance costs with savings from reduced waste collections and disposable packaging purchases. It should also measure bin contamination, reusable-container return rates, customer participation, convenience, and staff workload. Ultrasonic sensors may improve collection efficiency but do not directly reduce packaging consumption, while scanning bins may create queues or exclude packaging purchased outside LSE. Reusable-container schemes require washing facilities, sufficient container stock, and an accessible return network. Any app-based system must also protect users' personal data. Expansion should therefore take place only if the pilot demonstrates clear waste reduction, high participation, reliable technology, and acceptable financial and operational costs.

4. Pilot Scheme: Reusable Cups at LSE Catering

To assist the LSE Catering team in implementing change, we've proposed an actionable, four-stage pilot scheme centred on reusable cups. Building on existing systems such as LSE's branded KeepCups, a 25p levy on single-use cups, and the buy 9 get 1 free loyalty scheme, the rollout is designed to be practical and low-risk across just two school terms. To keep the rollout practical and low-risk, the scheme runs across just two school terms at the same high footfall café to control for location and seasonal factors, while also ensuring a high volume of transactions that makes the data more statistically robust and less susceptible to random variation. Additionally, data gathered could support scaling across LSE's cafés and restaurants or inform a more impactful next iteration.

Stage 1: Baseline Data Collection

Before the scheme launches, a baseline dataset must be established at the pilot outlet over the eleven weeks of LSE's Autumn Term. The following metrics should be recorded throughout the term by catering staff via the LSE Food Club app or a simple manual tally:

- Total hot drinks sold
- Disposable cups issued versus reusable cups used (disposable to reusable ratio)
- Weight or count of disposable cup waste collected from bins at the outlet

This baseline gives a pre-intervention C value for coffee cup disposal and a benchmark reuse rate against which Stage 3 results can be compared.

Stage 2: Scheme Set-Up and Design

The scheme should be integrated with the existing LSE Food Club app over the Christmas Break, with each reusable cup purchase tagged in the database with a new tag that cashiers can use to track scheme progress for each customer. The incentive structure is a loyalty mechanic: use a reusable cup nine times, and the tenth hot drink is free. This scheme could then be communicated through posters at the outlet, push notifications via the Food Club app, and social media through LSE-related media channels.

Stage 3: Treatment Data Collection

Furthermore, the treatment period should be carried out during the eleven weeks of LSE's Winter Term, while collecting the same metrics from Stage 1:

- Total hot drinks sold
- Disposable versus reusable ratio
- Weight or count of disposable cup waste
- Food Club app scans per transaction, to track scheme uptake and repeat use

The Food Club scan data is particularly valuable, as it allows uptake to be tracked at individual customer level, distinguishing between one-time trialists and habitual reusers, and providing a basis for calculating the DSI improvement attributable to the scheme.

It is important to note that although technology for the Food Club app currently exists, it has several points of failure in that students and faculty are unaware of the app and its usage, whilst also being difficult and often glitchy to use.

Stage 4: Evaluation and Decision-Making

At the end of the treatment period, the baseline and treatment datasets are compared on three dimensions. First, the statistical significance of the change in reusable cup ratio is assessed. Second, the qualitative stickiness of the scheme is evaluated through a short exit survey of regular customers at the outlet, asking whether they intend to continue using reusable cups and what barriers they encountered. Third, the financial viability is assessed by comparing the cost of the free-drink incentive against the reduction in disposable cup procurement and waste disposal costs.

If the scheme produces a statistically significant increase in reuse rate, positive customer feedback and a neutral or positive financial position, it should be rolled out to all LSE catering outlets in the following term. If uptake is positive but costs are prohibitive, the incentive mechanic can be adjusted (for example, extending the loyalty window to 14 uses) before a wider rollout. If uptake is negligible, the Stage 1 and Stage 3 data should be fed back into the DSI framework to recalibrate the contamination penalty for coffee cups, and the outlet-level bin signage and nudge interventions from Chapter 3 should be trialled instead.

5. Limitations and Considerations

While this project provides insights to address the problem statement, several limitations and considerations must be acknowledged. These constraints do not invalidate the findings but define the scope within which the results are applicable.

Key Constraints

- **Data availability:** The quantitative analysis proposed in this document is largely hypothetical. LSE does not currently collect the supplier order data, bin audit data or product-level misplacement rates needed to populate the PSI, DSI and OPSS indices with real values. The formulas are designed to be implementable once data collection is in place, but the indices cannot be meaningfully applied until that infrastructure exists.
- **Audit representativeness:** The existing LSE bin audit data (2011 and 2018) is outdated and limited in scope. The 2011 audit covered only the Library, and the 2018 audit was not conducted at a sufficient scale to be definitive (Beleva et al., 2021). Any extrapolation from these audits to campus-wide conclusions carries significant uncertainty, as spatial and temporal variation in waste generation means a single audit at one location may not reflect the full picture (Felder et al., 2001).
- **Contamination scoring:** The $P_{\text{contam|wrong bin}}$ parameter in the DSI requires estimates of how likely a misplaced item is to contaminate other material in the same bin. These estimates are currently qualitative and based on visual inspection notes. Without quantitative contamination data, this term introduces subjectivity into the index.
- **Supplier data access:** PSI calculation depends on LSE having access to detailed material composition data for each packaging product ordered. Suppliers may not readily provide this information, and the accuracy of PSI scores depends on the completeness and reliability of the data.

Recommendations for Future Work

The most pressing priority is establishing a regular, ideally annual waste audit programme covering multiple buildings and both academic terms to account for seasonal variation. This would provide the C values needed to compute accurate DSI scores for each product and to begin tracking contamination rates over time. Alongside this, LSE Catering should be engaged to provide supplier order data broken down by product type and packaging material, enabling PSI calculations to be populated for the highest-volume product lines first (coffee cups, disposable cutlery, food containers, and crisp packets, based on existing audit evidence). Once both indices are operational, OPSS scores can be computed and used to prioritise which products to target for procurement changes or consumer-facing interventions. Future work should also evaluate the impact of the reduction strategies proposed by comparing DSI scores before and after implementation, providing an evidence base for scaling the most effective interventions across the campus.

With More Time and Resources

Given more time and resources, this project could be substantially extended in several directions.

Real OPSS table. The most immediate extension would be populating the OPSS table with real values for the eight priority products (tissue, coffee cups, takeaway containers, disposable cutlery, plastic bottles, cans, crisp packets, and sandwich packets). This would require a dedicated bin audit across all five LSE campus zones over two academic terms, combined with a full supplier order from LSE Catering covering the material composition for each product line. With those two datasets, PSI and DSI scores could be computed for each product, and the OPSS table would shift from illustrative to actionable, giving LSE a prioritised list of products for intervention.

Longitudinal tracking. With sustained resources, the audit programme could be run termly, building a time-series dataset of C-values per product and per location. This would allow LSE to detect whether contamination rates are improving or worsening, attribute changes to specific interventions, and identify seasonal patterns, for example, whether contamination spikes during exam periods when footfall and consumption patterns change.

Reverse recycling machines. With sufficient capital budget, RRM installation at high-footfall locations (the Old Building, the Library entrance, NAB ground floor) would provide automated, real-time data capture on returned recyclables by material type and product, effectively replacing manual bin audits for those item categories with a continuous data stream and simultaneously providing a consumer incentive through the deposit-return mechanism.

Full material flow analysis. Extending the Picuno et al. (2021) approach to LSE specifically, modelling where packaging enters, how it flows through catering and consumption, and where it exits (by waste stream and off-site destination), would give LSE a systems-level view that the bin audit and order data alone cannot provide. This would require collaboration with Biffa (LSE's waste contractor) to obtain tonnage data by stream and destination, combined with the supplier order data and audit results, to construct a complete packaging mass balance for the campus.

Student and staff behaviour surveys. The barriers to correct disposal identified by Jacobsen et al. (2022) (i.e., convenience, habit, and lack of information) could be quantified specifically for LSE through a structured survey. This would allow reduction strategies to be targeted at the barriers that are most prevalent on this campus, rather than applying generic interventions that may not address the specific reasons why LSE students and staff misplace packaging.

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