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Design principles for city waste reduction: Addressing gaps in public reporting for zero waste

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ABSTRACT

As cities respond to growing demands of waste management, what and how information is publicly reported is becoming more important. Despite the evolution of sophisticated reporting systems, inconsistent, incomplete, and misunderstood waste management data create gaps in public reporting and accountability. The objective of this research is to explore gaps in public disclosures of information about an active city waste management system to identify and understand barriers towards a waste reduction target. This paper presents a case study through desktop analysis of waste management reporting within a local government area in Sydney, Australia, where waste is managed between the local government (the City of Sydney) and industry stakeholders. Three key barriers to transparent, inclusive, and auditable public reporting were identified as impacting the city waste reduction target: (i) an ambiguous target, (ii) conflicting and inconsistent waste data, and (iii) incomplete disclosures. Seven design principles are derived to support the myriad of stakeholders required to achieve more impactful city waste reduction targets and contribute to the limited empirical studies of zero waste implementation. Namely, (i) Transparency in Existing Sustainability Commitments, (ii) Disclosure of Material Flows, (iii) Inclusion of Stakeholder Relationships, (iv) Identification and Disclosure of Gaps in Public Reporting, (v) Development of Detailed Target Definition and Action Plan, (vi) Development of Baseline Waste Data and Progress Reporting Timeline, and (vii) Development of Detailed Budget to Achieve Targets.

1. Introduction and background

Housing 50 % of the world's population (Hoornweg and Bhada-Tata, 2012), cities disproportionally contribute to waste production by generating 70 % of the world's waste while covering a mere 2 % of its surface area (Zaman and Lehmann, 2013). Cities have complex waste management systems and are on the frontlines of waste reduction to address growing sustainability concerns (Hoornweg and Bhada-Tata, 2012; Zaman and Lehmann, 2013). Consequently, many cities have implemented waste reduction targets such as zero waste (Zaman, 2022) or circular economy (Kirchherr et al., 2017), while others have made commitments like the C40 Advancing Towards Zero Waste Declaration (C40, 2019); with 27 international cities, states and regions registered by 2019. Unlike towns (Ishuga et al., 2024) or regions (Lubello et al., 2025), cities (Abdulai et al., 2024) operate at larger scales of consumption and disposal that present unique challenges and require dedicated study. While previous city waste research has explored factors such as greenhouse gas (GHG) impacts associated with changes in waste management practices (Harfadli et al., 2025) and social impacts in cities transitioning towards circular economy policies (Vanhuyse et al., 2021), there remains a paucity of empirical studies on zero waste implementation (Pietzsch, et al., 2017).

Zaman and Lehmann (2013, p. 124) define zero waste as "no unnecessary and unwanted waste from a product at any stage of its life cycle".[1] Zero waste has previously been implemented as a city waste reduction target, with notable examples such as Adelaide, Boston, San

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[1] The definition of 'waste' in this research follows Zaman and Lehmann (2011) and Perey et al. (2018) in describing physical material that is perceived to contribute no value (economically, emotionally, or otherwise) to any stakeholder in the system under observation. The phrase 'waste reduction' in this research therefore refers to conscious action towards reducing the quantity of physical waste material and is inclusive of varying language used by different stakeholders within the system under observation (e.g., stakeholders working within a 'zero waste' target may use different language such as 'circular economy').

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Francisco, Shenzhen, and Stockholm achieving high levels of measurable success (Castigliego, et al., 2021; Ma, et al., 2023; Un-Habitat, 2010; Zaman, 2014; Zaman, 2015; Zaman and Lehmann, 2013). Despite these efforts, a zero waste target has not yet resulted in a city achieving "zero waste", indicating that there are substantive barriers to such efforts. Zaman (2015) argues that achieving 100 % diversion from landfill for a zero waste target is not currently possible, partly a consequence of the metrics designed to measure such attempts. To that end, the objective of this research is to explore gaps in public disclosures of information about an active city waste management system which has a zero waste target to identify and understand barriers towards a waste reduction target.

The City of Sydney's local government area and its 2030 zero waste target were selected as an exploratory case study using archival data. A desktop review was conducted to identify key available publicly reported data on the waste management system. Information was organised into visualisations, including mappings and a material flow analysis. Large gaps and inconsistencies in public reporting were encountered, preventing a complete material flow analysis to be estimated. Unlike the city waste management case study of Boston presented by (Castigliego et al., 2021), there was not enough available public-reported waste data to provide an overview of current and anticipated future waste flows. This observation aligned with the inconsistent reporting observed by (Qian et al., 2011) of waste management information from local governments in New South Wales. Notably, other studies that review waste material flows to analyse city zero waste targets have also reported limitations in secondary data (Castigliego et al., 2021; Ma, et al., 2023). Three key barriers to transparent, inclusive, and auditable public reporting were observed: (i) an ambiguous target, (ii) conflicting and inconsistent publicly reported waste data, and (iii) an absence of publicly reported waste data. Based on the case study findings, we derived seven design principles to support decision makers in developing and implementing more impactful city waste reduction targets.

This study is one of the first to critically explore the public data of an economically and environmentally significant local government area in a large global city with an active waste reduction target. The findings have implications for the burgeoning literature exploring the role of information in sustainable transitions. While there is limited attention in environmental management accounting literature investigating elements such as non-financial auditing in a local government context (Lewis, 2000), and on waste management (Adler et al., 2022; Ha and Mansi, 2023), there is limited literature that combines those features in the target setting, monitoring and reporting practices specific to waste management in a local government context. Integrated and streamlined practices to enable greater accountability, transparency, and stakeholder collaboration are increasingly important as international and domestic city waste reduction targets become more prolific.

This paper, therefore, contributes to environmental management accounting literature by exploring and describing an active city waste management system attempting a waste reduction target, paying attention to, *inter alia*, public reporting and accountability. This city case study further extends the work of Zaman and Lehmann (2013) and Zaman (2014) by exploring poor target communication, as well as conflicting, inconsistent and absent waste data as barriers in public reporting and, therefore, system change towards a city waste reduction target. The research, therefore, adds to the limited availability of empirical studies on zero-waste implementation (Pietzsch, et al., 2017) through a city waste reduction case study in Australia.

2. Methodology

Pietzsch et al. (2017) advocates for increasing the number of empirical studies to identify benefits, challenges, success factors, and variable factors related to zero waste. As the research objective is exploratory, we adopt a case study method (Yin, 2011). We selected the City of Sydney local government area for the empirical setting as it had an active city waste management system which has a zero waste target and public disclosure of information about the target and the system. Between 2018 and 2021, a structured desktop review of publicly available data was conducted to understand the waste flows in the waste management system with a view to exploring gaps in public disclosures of information, and to identify and understand barriers towards a waste reduction target.

Inspired by the method advocated by Gioia et al. (2013), the desktop review emphasised topical relevance of sources for inclusion over quantity and is less therefore extensive than traditional literature reviews. As a result, 12 texts were reviewed in this study and extensively analysed to inform the findings presented in this paper and the data presented in Tables A2–8 in the Supplementary Materials. Potential texts for inclusion in the desktop review were identified through a Boolean search in the browser 'Google' on 2 February 2021 with the following terms: ('City of Sydney' OR 'City Centre' OR 'Sydney CBD') AND ('Waste' OR 'Waste Management') AND ('Physical Waste' OR 'Waste Removal' OR 'Waste Movement' OR 'Measurement' OR 'Metric'). Texts of varying formats (such as academic journal publications and industry or government reports) were identified and reviewed using snowball sampling (Lecy and Beatty, 2012; Yin, 2011). Of the included texts, domestic government or commonwealth-funded reports were dominant, primarily featuring information regarding (i) population and demographics, (ii) geography and boundaries, (iii) policy and jurisdiction, or (iv) waste production and management. Following this initial search, the phrase 'zero waste' was used to search the City of Sydney website in October 2021 for any remaining related content that may have been missed by the desktop review. The secondary search only produced one item, a news article about picnics, that was deemed irrelevant to the research objectives.

Solid waste, key stakeholders, financing, and policy information was identified to better understand the city waste management system transitioning towards a 2030 zero waste target. A mixed-method approach was undertaken to understand and identify gaps in public disclosures of information (Creswell, 2014; Poth, 2018; Silverman, 2010; Yin, 2011). First, information was organised into visualisations (see Table A1 of the Supplementary Material) to understand the collective information across publicly reported information with a focus on mapping stakeholders, stakeholder relationships and waste management locations. This process revealed limited available information to effectively map the ecosystem and prompted a rigorous review of waste data in the publicly reported information.

Available publicly reported waste data was then organised into a material flow format and cross-referenced between sources. Data drawn from the desktop review and analysed for this study were compiled in tables A2, A3, A4, A5, A6, A7, A8 and A9 of the Supplementary Material. The data highlights annual total national waste production reported by the Australian government, and waste production in the City of Sydney area reported for the years 2012, 2014, 2015, 2017 and projected for the year 2030, as well as relevant stakeholders and governance. During analysis, inconsistent, incomplete, and misunderstood waste management data was observed, exposing gaps in public reporting and accountability.

2.1. Case study context: the city of Sydney's waste reduction target

Nationally, Australia has exorbitant waste consumption at a rate of 67 million tonnes of waste per annum (Commonwealth of Australia, 2018). Total national waste production in Australia grew by 134 % over eighteen years (32.4 Mt in 2002–03, 75.9 Mt in 2020–21); as publicly reported in the national waste reports, see Fig. 1. Despite this increase, Jones (2020) explains that waste management had yet to be maintained as a political priority for Australia at a national level, where constitutional and institutional factors to change in waste management systems have been previously identified. For example, Qian et al. (2011)

Fig. 1. National waste production reported by the Australian government over time. See table A2 of the Supplementary Material for the waste data used to generate this diagram. Decimal places have been rounded up to the nearest whole number. In instances of double reporting (e.g., 2006–07, 2010–11, and 2016–17), the most recent reporting for that year was used. Mt = million tonnes.

explored local governments from a state lens (NSW), lacking an exclusive focus on city waste management systems. Qian et al. (2011) observed that levels of public reporting on waste management from 12 local government case studies ranged widely; most case studies reported between 30 % and 60 % of the required information, one reported an anomaly of 95 % of the required information and three others reported 5 %-22 % of the required information. Inconsistent levels of reporting conflicted with the need for high-quality data and reporting outlined in Target 7 of the National Waste Policy Action Plan released by the Australian federal government to guide national waste management (Australian, 2019). Target 7 stated to "Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions" (Australian, 2019, p. 28). While the federal government recognised that reliable reporting on waste management is fundamental to informing change towards waste reduction in Australia, inconsistencies remained in local government's ability to meet those reporting expectations.

Comprehensive national waste reports on Australian waste management and recycling have been publicly reported for the last twelve years since 2010 (DEWHA, 2010). While there is a national standard for waste and resource recovery data and reporting, compliance is potentially limited because (i) the standard was provided for "opportunistic and voluntary adoption when convenient" (Blue Environment, 2021, p.1) and ii) it was only introduced relatively recently in 2021 (Blue Environment, 2021). As a result, each government agency (i.e., the states and territories) has different procedures, classifications, and levels of rigour in waste management (as well as documentation and reporting of waste production). According to Jones (2020), responsibility for waste in Australia is emphasised at state levels of government (who are characterised as reluctant to engage in policy learning) with advice and encouragement of the federal government as support. This dynamic leaves local government without constitutional power to change or contribute directly to shaping broader waste policy (Jones, 2020).

As Australia's highest-populated state capital city, Sydney is socially, financially, and politically important to the national landscape (Australian Bureau of Statistics, 2019). The name 'Sydney' is used to describe two different boundaries in the region: (i) 'Greater Sydney' describes the 12,368 km^2 geographic region containing many local government areas (City of Sydney, 2017a), and (ii) 'City of Sydney' describes the 26 km^2 local government area (City of Sydney, 2019a, 2017b) south of the Sydney Harbour Bridge and includes the central business district (CBD), see Fig. 2. The City of Sydney is presented as a case study in this paper to explore an active waste management system transitioning towards an ambitious waste reduction target: 'Zero Waste by 2030'.

As a dense central business district (CBD), the City of Sydney local government area houses 240,229 people, 20,000 businesses, 437,000 jobs and generates more than 25 % of the state's (New South Wales) gross domestic product (GDP) (City of Sydney, 2017a, 2017b, 2017c, 2019a). The City of Sydney local government area contains 33 suburbs (City of Sydney, 2019b) and stands on the ancestral lands of the Gadigal and Guring-gai people of the Eora Nation (First Nations people of Australia). With a dense population of approximately 5000 people per km^2 (City of Sydney, 2018), the area provides a concentrated focus area, being 4.6 % of the Greater Sydney population (City of Sydney, 2019a) (see Fig. 2).

Waste management in Australian cities has received little attention in the literature. For example, Zaman's (2015) review of zero waste-related papers looking for holistic approaches to waste management showed only eight papers with Australian case studies (out of 96 papers reviewed published between 1995 and 2014). Sydney, a significant waste generator, was not included in the eight papers with Australian case studies.[2] To better understand waste management in Australia as a nation, the City of Sydney is an appropriately concentrated and significant case study as a leader in Local Government.

3. Results and discussion

Our analysis of the case study identified three key barriers to transparent, inclusive, and auditable public reporting: (i) an ambiguous target, (ii) conflicting and inconsistent waste data, and (iii) incomplete disclosures. We discuss these in turn below.

3.1. Poor target communication as a barrier in public reporting

The City of Sydney's waste reduction target of 'Zero Waste by 2030'

[2] While Lehmann (2011) includes a brief case study of waste in New South Wales (3 paragraphs) that mentions landfills used by Sydney, there is no assessment of the waste management system, nor any further information about Sydney outside of landfill overcapacity predicted for 2015.

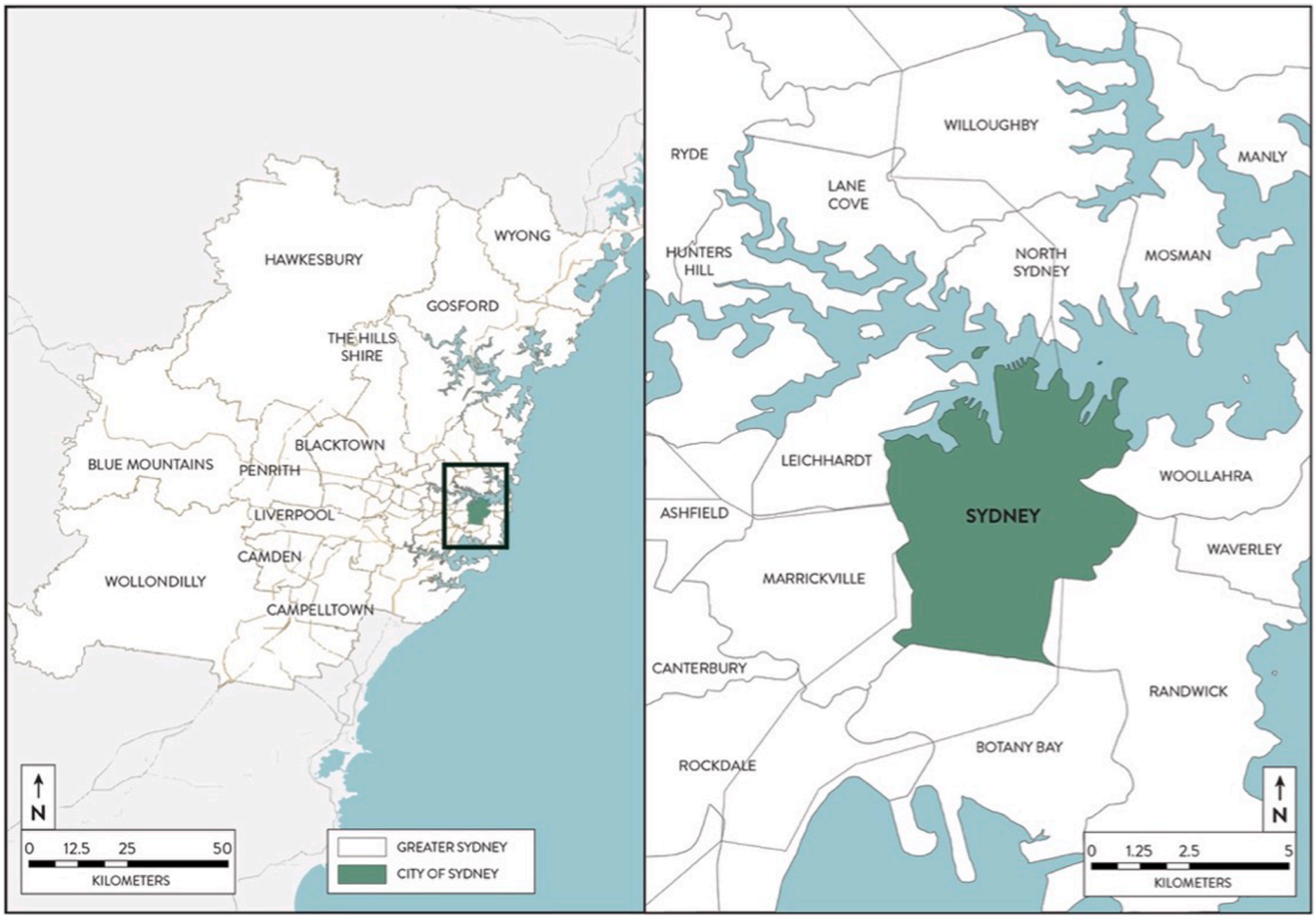

Fig. 2. Scale of the City of Sydney within the Greater Sydney area, adapted from (Hu, 2015, p. 4552).

for the local government area is ambiguous as a result of poor communication in public reporting. There are three major factors impacting this communication barrier: (i) that the target is difficult to locate in online public reporting, (ii) that the description of the target can only be located within lengthy report attachments and does not disclose which waste streams the target addresses, and (iii) that the second informal target addressing the remaining 90 % of the waste produced (over 60 million tonnes per annum) in the local government area is not clearly communicated or enforceable. The highly complicated structure of the target and the absence of transparent, inclusive, and auditable information (as described below) creates uncertainty regarding whether the zero waste target could be obtained or validated.

Firstly, the target is difficult to locate in online public reporting. For example, the only item on the City of Sydney website that was located with the search phrase 'zero waste' was a brief blog titled 'How to have a zero-waste picnic,' posted in September 2021 (City of Sydney News, 2021). While other references to 'zero waste' exist within descriptions and reports (i.e., inside attached documents available for download), they could not be quickly found by searching for the target's title. Difficulty locating the target on the City of Sydney's website indicates a barrier for stakeholders to access and initially engage with the target. A clear description of the 'Zero Waste 2030' target can only be found within extensive reports attached as supporting PDFs on the website: 90 % diversion of solid waste from landfills, as set in 2010 under the Sustainable Sydney 2030 strategy (City of Sydney, 2017c, 2017a). Action towards the target by the City of Sydney was also difficult to locate within extensive reports attached as supporting PDFs on the website, and any planned activities described were vague without a method of measurement or a monitoring strategy. Access to this information requires expertise navigating the City of Sydney website and information storage systems. The difficulty to access basic information on the target and auditability in measuring or monitoring progress is indicative of a lack of transparency and a communication barrier for stakeholders to engage with the target and support system change toward waste reduction.

Secondly, the description of the 'Zero Waste 2030' target found in the lengthy report attachments does not disclose which waste streams the target addresses. Local governments in the state of New South Wales are only responsible for and therefore have authority over, solid waste that it directly manages. The 'municipal' waste the City of Sydney is directly responsible for includes solid waste from households and (i) city parks, streets, and public places, (ii) city-managed properties, (iii) construction and demolition generated and managed by city operations (City of Sydney, 2017c). Municipal waste directly managed by the City of Sydney represents 6.7 million tonnes per annum (City of Sydney, 2017c), which is only 10 % of the total waste generated in the local government area (67 million tonnes per annum (Commonwealth of Australia, 2018)). The zero waste target, therefore, only addresses the 10 % of waste from the local government area that the City of Sydney directly manages; a marginal figure compared to the remaining 90 % of waste production that is not addressed by the target. If the City of Sydney were to achieve the formal 2030 zero waste target across

municipal waste, it would only reduce the total waste produced in the local government area in 2017 and 2018 by 9 %.[3] This finding aligns with the relatively small scale of municipal waste compared to the total outputs from most cities (typically 10 %) as Wilts et al. (2019) observed. In addition to being difficult to locate, the scale of waste that the target addresses (including its possible impact if successful) is not made explicit to stakeholders. Oosthuizen et al. (2019) write that public reporting relies on the consistency of the information reported and how it is interpreted. This lack of transparency through the undisclosed scale of waste that the target addresses contributes to the communication barrier for stakeholders to engage with the target and support system change toward waste reduction. The limitation of auditability through minimal local government jurisdiction (see Table A9 of the Supplementary Material) over waste production sources (such as construction and demolition, or commercial and industrial) reinforces this barrier to change towards a waste reduction target. Increasing privatisation of Australian waste management continues to reduce the level of influence local governments have in shaping system change towards waste reduction and, therefore, increase the importance of clear communication and collaboration with stakeholders across the system.

Finally, unclear communication and a lack of enforceability were observed in a second informal target that addresses the remaining 90 % of waste production from (i) residential, (ii) commercial and industrial, and (iii) construction and demolition (City of Sydney, 2017c) sources. The only observed evidence that the distinction between the formal and informal target was clearly communicated to stakeholders through publicly reported information was an extensive report attached as a supporting PDF on the City of Sydney's website. The absence of evidenced consultation or co-design is significant as the City of Sydney does not have jurisdiction (see Table A9 of the Supplementary Material) to enforce this target across 90 % of waste production across the local government area, and communication is vital to engage and support stakeholders who are responsible for transition towards the target. The absence of transparency and inclusive consultation across an unenforceable target that addresses the bulk of waste production for the local government area is a large contributor to the communication barrier for stakeholders to engage and support system change toward waste reduction.

3.2. Conflicting and inconsistent data as a barrier in public reporting

Public reporting on the waste source descriptions and measurements relating to the City of Sydney's waste reduction target of 'Zero Waste by 2030' was found to be conflicting and inconsistent. Three linked reports published by the City of Sydney in 2017 were the focus texts reviewed: 'Adopted Sustainable Sydney 2030' (City of Sydney, 2017a); 'Environmental Action 2016–2021' (City of Sydney, 2017b); and 'Leave Nothing to Waste' (City of Sydney, 2017c). There are two major factors impacting this data barrier. First, the City of Sydney reports conflicting descriptions of waste categories across different documents published in the same years. For example, waste data from 2015 to 2016 reports 275 tonnes from the City of Sydney's 'managed properties' (City of Sydney, 2017b) and 400 tonnes from the City of Sydney's 'buildings' (City of Sydney, 2017c), see Table A5 of the Supplementary Material. Another example includes the waste data from 2015 to 2016 that reports 723 tonnes from the City of Sydney's 'parks' (City of Sydney, 2017b) and 11,000 tonnes from the City of Sydney's 'parks, streets, and public spaces' (City of Sydney, 2017c), see Table A5 of the Supplementary Material. In both examples, the descriptors used are similar in wording yet report vastly different weight measurements and prevent reconcilable accounting of waste reporting for that year (2015–16). Conflicting descriptions across waste production measurements from the same year prevents auditability (with a high risk of double-reporting) and is a barrier to public reporting on progress towards the waste reduction target. Waste data was one of many sources of conflicting data reported across these reports. For example, the population in the City of Sydney local government area was reported as both 205,339 (City of Sydney, 2017a) and 210,000 (City of Sydney, 2017b), then projected to reach 300,000 by 2030 (City of Sydney, 2017a) and 280,000 by 2036 (City of Sydney, 2017b). Additionally, smaller waste streams such as 'illegal dumping', 'e-waste', and 'New Year's Eve street waste' are included in the waste data reporting without specifying which overarching waste streams these smaller units belong within and posing further risks to double-reporting. These reporting conflicts demonstrate an oversight in cross-referencing information publicly reported by the City of Sydney and the need for increased transparency throughout the organisation.

Second, inconsistencies in measurement across waste streams and sources are reported on by the City of Sydney across different documents and years. For example, the City of Sydney reported 700,000 tonnes of waste production from the 'commercial & industrial' waste stream in 2017 and did not report any waste data from this stream in 2015–16 (or any other year), see Table A6 of the Supplementary Material. This inconsistency in waste data reporting was observed in projections and direct annual reporting. For example, the City of Sydney projected that in 2030, waste production from the 'construction & demolition' waste stream would reach 1,500,000 tonnes, yet presented no waste data for this waste stream in 2015–16, 2017, or any other year, see Table A7 of the Supplementary Material. The 'construction and demolition' waste listed in Tables A5 and A6 of the Supplementary Material relates to municipal construction and demolition projects (not the industry waste stream of the same name). Additionally, 700,000 tonnes of 'construction and demolition' waste was reported as a mixed source where the City of Sydney claimed responsibility for 400,000 tonnes and did not explain the remaining 300,000 tonnes, see Table A6 of the Supplementary Material Further evidence of inconsistent reporting was observed where waste data was reported in percentages of unknown total waste quantities. For example, the City of Sydney reported percentage ratios of eight different waste sources within the 'residential general waste bin contents' waste stream for 2017 and the 'commercial & industrial' waste stream for 2015–16 (City of Sydney, 2017c) without a source measurement of waste data that the percentages were based on, see Table A5 and A6 of the Supplementary Material. This lack of transparency through inconsistent waste data contributes to the barrier to public reporting on progress towards the waste reduction target. The limitation of auditability through inconsistent waste data also reinforces this barrier to change towards a waste reduction target. Absence of clear, consistent and categorised waste data does not provide strong evidence of strategic waste reduction by the City of Sydney.

The impact of inaccurate reporting extends larger than public perception and economic incentives for commercial parties. National public reporting is reliant upon the accuracy, completeness and validity of data provided by the states and territories (Oosthuizen et al., 2019). In exploring factors that shape the political priority of waste management in Australia, Jones (2020) linked weak evidence in reporting (e.g., relying on estimates and surveys with questionable validity) as restricting federal, state and local governments from understanding the scale of landfills in their waste management systems. That absence of reliable and completed data also provided the opportunity for private industries to leverage further power in the system and use "selective data to promote the view that positive developments are occurring without the need to provide testable results" (Jones, 2020). Therefore, the accuracy of public reporting on waste from local government areas has much larger ramifications outside their geographic jurisdiction, affecting the validity of information used at a federal policy level and relied upon by a broad set of stakeholders.

[3] This 9 % is an estimate that has been calculated using the waste production statistics provided by City of Sydney reports in 2017 and 2018. A more accurate calculation might be attained by using waste production data from 2010 when the zero waste target was first set (City of Sydney, 2017c).

3.3. Incomplete disclosures as a barrier in public reporting

Notable incomplete disclosures of waste movement or budgeting from the City of Sydney and any supporting public reporting from key industry stakeholders were observed as problematic for understanding planning, progress, or any intention of change towards the waste reduction target. Three linked reports published by the City of Sydney in 2017 were the focus texts reviewed: 'Adopted Sustainable Sydney 2030' (City of Sydney, 2017a); 'Environmental Action 2016–2021' (City of Sydney, 2017b); and 'Leave Nothing to Waste' (City of Sydney, 2017c). There are two major factors impacting this data barrier. First, an absence of public reporting on waste movement or budgeting for system change towards the waste reduction target was observed. In particular, the location of waste material and budgeting for change towards the waste reduction target was not clearly reported. For example, the location of material waste transported through known checkpoints, such as landfill destinations, was not reported. This is despite acknowledgements that localised landfills in Greater Sydney are rapidly decreasing in capacity (City of Sydney, 2017b) and the use of five landfill cells across the state, including Jack's Gully, Genesis Facility at Eastern Creek, Lucas Heights, Belrose, and Woodlawn landfill at Tarago; see Fig. 3 (Sohkhlet and Nagargoje, 2019). Exacerbating this gap in public reporting is the absence of key information on the locations, capacities, and managing contractors of known checkpoints of waste in the system (such as facilities for recycling from yellow bins and organics waste from green bins). Not disclosing key information about the waste system inherently conceals the level of influence that industries have in the waste management system. For example, Veolia is a private organisation that operated the Woodlawn landfill, which receives the largest amount of waste in the country (400,000 + tonnes per year) and is accessed by Greater Sydney (Sohkhlet and Nagargoje, 2019). If a company such as Veolia also has a contract with the City of Sydney to treat and dispose of waste for the local government area, the absence of disclosure from the City of Sydney could hide the influence that a company with a monopoly styled position in the industry has on internal decision-making regarding waste reduction.

Explanations of waste management spending (including financial records and budgeting projections) were absent from public reporting by the City of Sydney. For example, waste disposal charges were projected by the City of Sydney to cost A$28.8 million in 2028–2029 (A$6.7 million more than the projected A$22.1 million in 2019–2020) (City of Sydney, 2019b, 2020). No discussion was included to outline how these funds would be spent or why waste disposal charges would increase despite the 'Zero Waste by 2030' target being 90 % diversion from landfill (i.e., less waste by the year 2028). Additionally, when the 2019–2020 budget total was calculated with 1 % inflation to 2028–2029, the resulting projection was A$24.2 million – considerably less than the A$28.8 million budgeted for by the City of Sydney; see Fig. 4. The absence of explanations for waste management spending by the City of Sydney is a large contributor to the barrier to public reporting on progress towards the waste reduction target. The transparency required to demonstrate commitment and progress towards an ambitious target such as 'Zero Waste by 2030' was not reflected in the available financial reporting from the City of Sydney. The lack of discussion around future waste budgeting directly impacting the 'Zero Waste by 2030' target exposes the City of Sydney to criticism around the depth of consideration given to the waste reduction strategy. Waste management spending was one of many financial data points that were absent from the City of Sydney's public reporting. Income from service charges (such as rental trucks, compactors, or bins) was publicly reported; however, the 'tipping fees' associated with these services were vaguely listed as "fee +GST" (City of Sydney, 2019b, p.117).[4] The absence of this information is relevant to the role of industry in waste management, where tipping fees in most local government areas around Australia are calculated by private organisations that hold contracts for waste processing and disposal. These reporting gaps highlights a potential lack of attention placed on accountability for local government waste management services, where information that would support collaboration with stakeholders within the local government area was not disclosed.

Second, despite the disclosure of nineteen key stakeholders in the City of Sydney's waste management system through reviewed public reporting, no waste data that would support or contradict the information provided by the City of Sydney was reported by those stakeholders. The nineteen stakeholders identified through public reporting were identified by either being named by the (City of Sydney 2017a, 2017b, 2017c, 2018, 2014–15), or named by related sources (James et al., 2019; Sohkhlet and Nagargoje, 2019), see Table 1. Of the information collected about these stakeholders, no data around waste weight or associated costs was observed, see Table A8 of the Supplementary Material. Similarly, no supporting data about contributions from different waste streams, locations or processing of waste, or the role of specific contractors involved in the target was observed. This lack of transparency by other key stakeholders in the system contributes to the data barrier impacting system change toward waste reduction. As a by-product, the lack of transparency from industry stakeholders prevents the constituents and practitioners alike from understanding the scale and role of influence that different players in the system may have in government decision-making around waste management systems.

The incomplete disclosure of public reporting information regarding stakeholders highlights the need for social systems mapping, which Ackoff (1994) argues is vital in relation to human stakeholders to provide a more holistic understanding of the waste management system. This prevented the inclusion of nuanced and unique perspectives on the waste reduction target that can inform understandings about the city waste management system as it transitions towards a waste reduction target.

3.4. Discussion

The above findings and discussion are consistent with Lamberton (2005) in that we suggest that for well-informed sustainable change to occur in the waste industry, transparent, inclusive and auditable reporting is required. Lamberton (2005) calls for radical change in sustainability accountability information through the implementation of a comprehensive sustainability accounting framework with five key themes: (i) objectives of the framework, (ii) underlying principles, (iii) data capture and measurement techniques, (iv) reporting formats, and (v) qualitative attributes. The fifth theme of Lamberton's (2005) framework draws directly from the GRI Guidelines (Global Reporting Initiative, 2002) to emphasise transparency, inclusiveness and auditability as primary attributes. Our findings are also consistent with that of Qian et al. (2011), who observed inconsistent reporting of waste management information from local governments across the state of New South Wales. These processes could support decision-makers in overcoming key challenges associated with zero waste targets.

Furthermore, Environmental Management Accounting has begun addressing these reporting needs (Adler et al., 2022; Ha and Mansi, 2023; Lewis, 2000; Qian et al., 2011). Initially responding to concerns for ecological degradation, environmental management accounting has been applied to waste management and other non-financial auditing processes to better measure and understand the impacts of organisations. For example, in a local government context, Lewis (2000) explores and proposes using environmental audits (non-financial) in the UK. Other examples of this work exist in a corporate context where researchers like Ha and Mansi (2023) have reviewed the nature and extent of waste management reporting for Australian metals and mining companies. Similarly, Adler et al. (2022) reviewed solid and liquid waste disclosure reporting from the top 30 companies in India between 2012

[4] GST stands for 'Goods and Services Tax'.

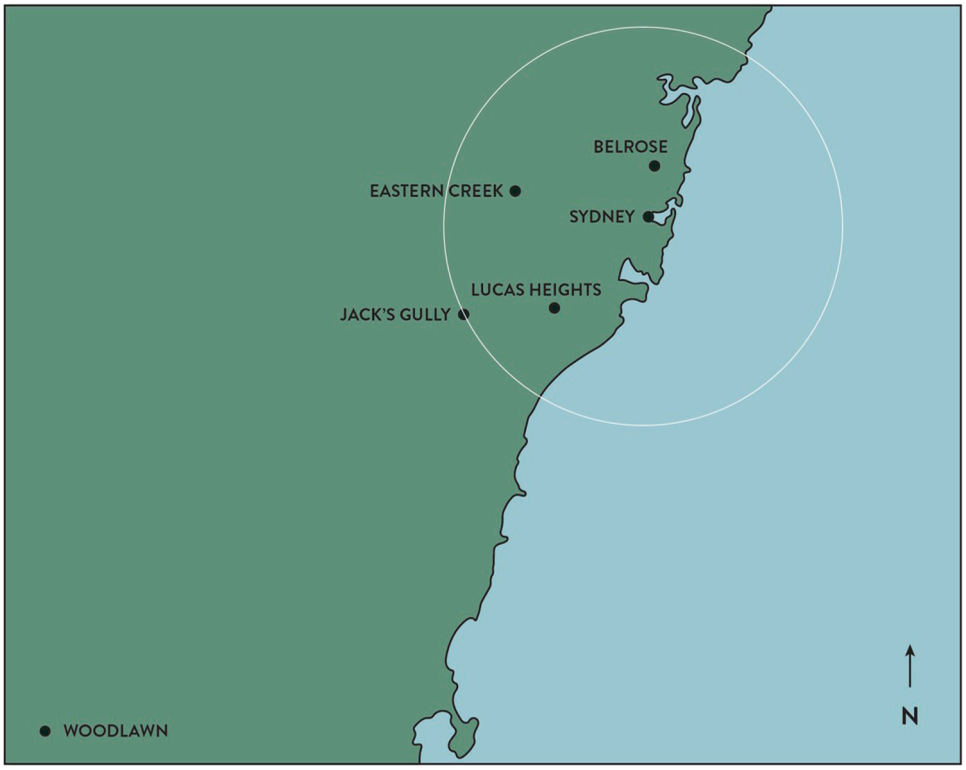

Fig. 3. Primary landfills used by Greater Sydney and geographic proximity, adapted from Sohkhlet and Nagargoje (2019, p. 5). Note: here the white circle represents a 50 km radius from Greater Sydney.

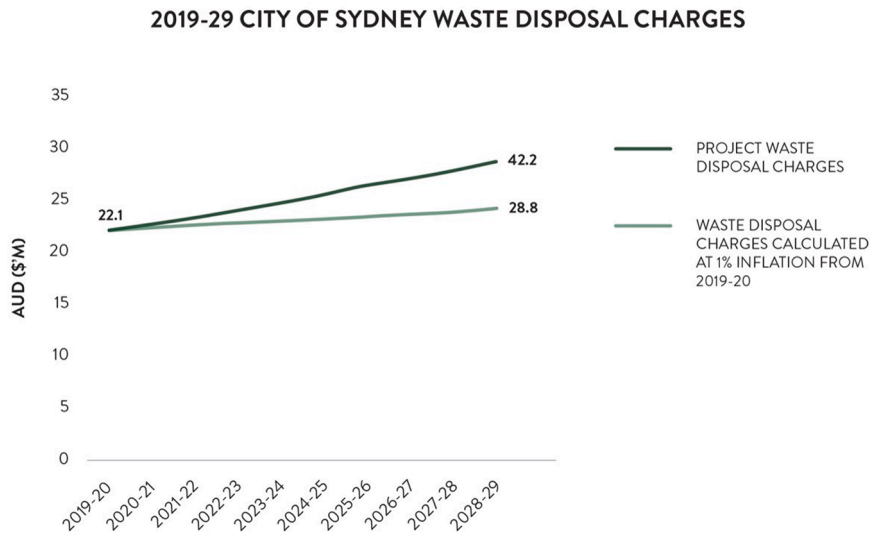

Fig. 4. Projected inflation of waste disposal charges for the City of Sydney 2019–2029. Waste disposal charges are calculated at 1 % from 2019 to 2020, calculated using the 2019–2020 operating expenses published in both the 'Operation Plan 2019/20' and the 'Revised Operational Plan 2019/20' by the City of Sydney (City of Sydney, 2019b, 2020). Note: charges are represented in Australian dollars at $'M.

and 2018 as measured by the Bombay Stock Exchange (BSE) benchmarking index called 'SENSEX'. In reviewing the role of environmental audits in UK local governments, Lewis (2000) identified that auditable measurement systems focus more on performance towards those measures rather than sustainable development. Jones (2020) identified that unreliable and incomplete data was a vulnerability in the Australian government's public reporting on waste that facilitated private industries to leverage power in the system by manipulating data that presents a narrative that suits their needs without the accountability of testable results. Despite such strides, this case study reveals a substantial gap between what data structure would be desirable to support transitions to sustainability targets such as zero waste, and what is observable in practice.

3.5. *Seven design principles*

Critical knowledge gaps such as those identified above present a barrier to achieving waste reduction targets, and there are few empirical studies of zero waste implementation to guide pathways towards more sustainable futures. Increased transparency, inclusiveness, and

Table 1
Disclosed stakeholders in the City of Sydney's waste management system.

Location of Stakeholder Disclosure	Stakeholders
Named by the City of Sydney	1. Lord Mayor Clover Moore
	2. Workers, businesses, residents, visitors and students in the City of Sydney local government area
	3. City of Sydney street cleansing crews
	4. City of Sydney rangers
	5. C40 Climate Leadership group (C40)
	6. Green Villages
	7. Garage Sale Trail
	8. Reverse Garbage
	9. Bower Reuse and Repair Centre
	10. NABO
	11. Sell Buy Swap
	12. Open Shed
	13. Better Building Partnership (BBP)
	14. City Switch
	15. Closed Loop Environmental Solutions
	16. Smart Green Apartments program, and
	17. The NSW Container Deposit scheme.
Named by related sources	18. The Environmental Committee of the City of Sydney Council
	19. The Freecycle Network.

auditability (Lamberton, 2005) in the governance of waste management systems can support progress towards waste reduction targets. Following the approach of Pham et al. (2020), seven design principles have been derived to reflect the barriers observed in this study, see Table 2. An analysis of the city case study performance against the seven design principles can be found in Table A10 of the Supplementary Material.

The first four design principles aim to facilitate users' design of governance for the waste management system and understand the context that shapes the waste reduction target under review. Following these, the later three design principles aim to support users in navigating the scope and application of the waste reduction target over time. The incomplete disclosure of crucial information about waste management governance makes achieving a zero waste target difficult. Future research could include the extension and application of these design principles to a city waste reduction target using a participatory action research approach following Kemmis et al. (2014) for implementation, reflection and iteration of the design principles in different contexts.

4. Conclusion

This research contributes to addressing the limited availability of empirical studies on zero waste implementation observed by Pietzsch, et al. (2017). In response to the case study findings, seven design principles are presented to support the development and implementation of impactful city waste reduction targets. The case study identified gaps in public disclosures of information about a waste management system in a city local government area and is the first such assessment to be undertaken in Australia's most highly populated city, Sydney. Extant literature suggests that government policy impacts waste reduction performance (Marques and Teixeira, 2022) and the role of public policy 'agendas' frame action towards waste reduction (Zaman and Newman, 2021). While Australia was reported having a high representation of regulation across the categories of 'people', 'future', and 'effectiveness' in comparison to the 38 other countries profiled in the OECD (2025) Indicators of Regulatory Policy and Governance Survey 2024, regulation around the category 'planet' which was underrepresented.

Three key barriers to transparent, inclusive, and auditable public reporting were identified as impacting the city waste reduction target: (i) an ambiguous target, (ii) conflicting and inconsistent waste data, and (iii) incomplete disclosures. These barriers present challenges for

Table 2
Design principles for developing and implementing city waste reduction targets.

Category	Design Principles	Description
Waste Management System	Design Principle 1: Transparency in Existing Sustainability Commitments	– Lists existing global, national, state, or local legislation and targets that impact the waste management system. – Includes a brief discussion on the anticipated impact of existing political contexts on the waste management system and its waste reduction target
	Design Principle 2: Disclosure of Material Flows	– Geographically maps waste movement through the city, including consumables entering and waste exiting the city boundaries. – Includes waste streams that have unknown quantities. – Includes waste at different stages such as generation, collection, processing, and final location
	Design Principle 3: Inclusion of Stakeholder Relationships	– Lists key stakeholders that impact the waste management system under review. – Includes engagement and inclusion strategy for each stakeholder in the waste reduction target. – Includes direct engagement and inclusion of identified stakeholders with the waste reduction target through events, workshops, focus groups, interviews, surveys, or other methods.
	Design Principle 4: Identification and Disclosure of Gaps in Public Reporting	– Lists observed gaps in public reporting from the city's local government and relevant waste management stakeholders. – Includes strategies for how the knowledge gaps might be addressed through design principles 5, 6, and 7.
Waste Reduction Target	Design Principle 5: Development of Detailed Target Definition and Action Plan	– Develops a detailed target definition and action plan for public reporting including boundaries aroundcharacteristics such as geography, politics and time. – Develops a rigorous action plan for implementing and measuring the waste reduction target, including key measurable milestones and instructions that different internal or external stakeholders in the system can follow.
	Design Principle 6: Development of Baseline Waste Data and Progress Reporting Timeline	– Develops baseline waste data for the target that includes all waste streams addressed by the waste reduction target and agreed metrics of measurement. – Develops a timeline for public reporting on target progress that includes interim reporting deadlines for public reporting, and allocated responsibility for waste data collection. – Public reporting of any contracted waste management stakeholders impacted or involved in the waste reduction target should including organisational or department level disclosure, their role in the

(*continued on next page*)

Table 2 (*continued*)

Category	Design Principles	Description
		waste management system and the length of their contract.
	Design Principle 7: Development of Detailed Budget to Achieve Targets	– Develops a detailed target budget that is flexible to meet the changing needs of the waste management system over time including scheduled public reporting intervals that align with the action plan developed in design principle 5.

environmental management accounting and barriers to fostering sustainable waste reduction changes in cities. Poor communication and inaccurate reporting provide a false sense of achievement and shelter public forums from discussing larger-scale system change. The implications of failing to disclose reporting evidence that sustainability targets have not engaged in greenwashing are increasingly relevant in light of the International Sustainability Standards Board (ISSB) reporting standards that came into effect on January 1, 2024 (IFRS Sustainability, 2023). Increased transparency, inclusiveness and auditability in the public disclosures of information (Lamberton, 2005) through a city-wide environmental management accounting system is therefore required to (i) inform system change towards more sustainable futures and (ii) support collaboration between different stakeholders in the system to engage with progress. Gazeau et al. (2024) highlight the need for updated system analysis tools in the transition from linear to circular waste management systems. Similarly, shifting city waste management approaches towards waste reduction require updated approaches to waste target design, monitoring, and implementation.

Furthermore, this paper featured a city local government case study to better understand the role of public policy in city waste reduction. Future research could explore the role of other stakeholders such as industry and community waste experts to develop a more holistic perspective following recommendations by Hannon and Zaman (2018), Seadon (2010), and Zaman (2015).

CRediT authorship contribution statement

Jarnae Leslie: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paul James Brown:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Susanne Pratt:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Melissa Edwards:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.clwas.2025.100326.

Data availability

No data was used for the research described in the article.

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