UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Understanding System Change: Assessing Sydney's Waste Reduction Target

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Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of A/Prof Paul J. Brown, Dr Susanne Pratt, and A/Prof Melissa Edwards.

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February 2023

Certificate Of Original Authorship

I, Jarnae Leslie, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the TD School at the University of Technology, Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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This research is supported by the Australian Government Research Training Program.

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Abstract

As mass contributors to global waste production, many cities in the OECD countries are setting waste reduction targets such as zero waste. Many of these targets rely on waste diversion as a core metric and do not acknowledge other factors influencing change. A holistic system approach explores the interrelated factors that impact a city waste reduction target to better understand change in a waste management system.

This thesis investigates what system change in city waste management looks like when undergoing a waste reduction target. Specifically, it addresses two objectives. Firstly, to explore and describe an active city waste management system attempting a waste reduction target; see Chapter Three. Secondly, to explore and describe key factors that may impact an active city waste management system attempting a waste reduction target; see Chapter Four.

A desktop review, semi-structured interviews and focus groups were conducted across Chapters Three and Four to address the two research objectives. Transdisciplinarity was the philosophical perspective applied to this thesis. The methodology featured participatory action research and included a systematic inductive approach to data analysis. Chapters Three and Four together present one city case study: the City of Sydney local government area and its 2030 zero waste target.

'Zero waste' as a concept was observed acting as a boundary object and was followed across the Chapters Three and Four in the thesis to understand system change in the city case study waste management system. Key findings from the desktop review in Chapter Three include three challenges to

implementing and measuring the case study target: 1) poor communication of the target by the City of Sydney; 2) conflicting and incomplete public reporting of waste data by the City of Sydney; and 3) an absence of public reporting of waste data by other key stakeholders. Key findings from the semi-structured interviews and focus groups in Chapter Four include fourteen factors impacting change in the city waste management system toward its waste reduction target and were distributed across six factor categories: 1) financing; 2) pivotal events; 3) communication; 4) physical surroundings; 5) leadership; and 6) local government employment. Findings from Chapters Three and Four together presented eighteen factors that were developed into a conceptual model that acts as a navigational tool to understand the city case study waste management system. The conceptual model features three interacting domains of change: 'materiality', 'reporting', and 'sentiment'. Zero waste as a boundary object was observed in the relationships between these domains.

This thesis extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) by taking a holistic approach to assess a city waste management system in relation to its waste reduction target. The research contributes to the limited literature that holistically assesses a city waste management system with a waste reduction target that includes a social system mapping approach. Further, this is the first holistic study of an active waste management system in Sydney, Australia.

Acknowledgments

Here I would like to acknowledge the Country, funding and people that supported the production of this thesis.

1. Acknowledgment of Country

I would like to acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. I would like to extend this acknowledgement to 1) the Gadigal and Guring-gai people of the Eora Nation upon whose ancestral lands the University of Technology Sydney (UTS) now stands, and 2) the Dharawal people of the Eora Nation upon whose ancestral lands much of this thesis was written. I would also like to pay my respects to the Elders past and present, acknowledging them as the traditional custodians of knowledge for this land.

2. Acknowledgment of Funding

Thank you to the Australian Government and the University of Technology Sydney, for providing the environment, facilities, and financial support to complete this thesis. This research was supported by an Australian Government Research Training Program Scholarship. Thank you to the Centre for Business and Social Innovation (CBSI) at the UTS Business School for their financial support.

3. Acknowledgment of People

Thank you to my primary supervisor, A/Prof Paul Brown, who encouraged me to enter the PhD program and who taught me that not all research is good research, not all good research is valuable, and not all valuable research is funded. To my co-supervisors Dr Susanne Pratt, who continues to inspire me with her optimistic, sage guidance, and to A/Prof Melissa Edwards, who encouraged me to seek out understanding from those who are typically overlooked. Thank you for combined time and effort guiding me on this research journey.

Thank you to Samuel Yu for being my patient sounding board, a source of encouragement and laughter as well as being a walking thesaurus, barista and conveyer of food. You helped me through some of the most difficult months at the end of this thesis and were a constant reminder of the optimism we should hold for the future; thank you. To Mariana Zaferiakopoulos for your empathetic, kind, and inspiring guidance in balancing research with life, and for meticulously proofreading my final drafts. To Deborah Sutton and Megan Smith for being both grammatic guides and Zoom writing partners late into the night. To Jennifer Binetter for being a relatable submission partner as we worked towards finalising our theses.

Thank you to my entire (and big) family for instilling a love of learning, understanding, and helping others. To my mother Christine Leslie, whose creativity, wit, and endless work ethic continues to inspire me to help improve the world with curiosity and dedication. To my father Darryl Leslie, who taught me to appreciate each person as an individual with value and that money, titles or opportunity cannot define us as people. Together, your encouragement and guidance allowed me to gain a formal education and ultimately this thesis; thank you. To Bram Leslie, Liana Leslie and Maple Leslie for your excitement and company along the way.

Thank you to the TD School community (formerly the Faculty of Transdisciplinary Innovation) who taught me that collaborative research, while challenging, can ultimately provide richer insights into our complex world.

Thank you to Dr Christina Houen of Perfect Words Editing for your work in copy editing this thesis according to the guidelines of the UTS and the Institute of Professional Editors (IPEd). Thank you to Doria Katos for her work graphicly producing diagrams for this research.

Thank you to the research participants who cannot be named here for ethical reasons. Your combined passion for change, determination in the face of adversity and combined decades of wisdom have gifted me insights, not only into the research area, but into humanity.

Thank you to the reviewers of my stage assessments and the examiners of my thesis for your feedback that allowed me to strengthen this body of work and contribute to knowledge.

As can be said of any acknowledgements section, there are more people who have impacted this PhD journey than can ever be listed. Thank you to many others who are not named here for your support.

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Chapter 1: Introduction

Growing waste production escapes poorly planned or overcapacity control systems and impacts our environment and health. The research in this thesis intends to support sustainable futures development by using a holistic approach to understand system change. A case study was undertaken to assess a city waste management system undergoing a waste reduction target. The research addresses the meta-research question: "What does system change in city waste management look like when undergoing a waste reduction target?". This question is addressed through Chapters Three and Four, which together form one case study: the City of Sydney local government area and its 2030 zero waste target.

Sydney is not only Australia's most populated city (Australian Bureau of Statistics, 2019) but it is socially, financially and politically important to the national landscape. The City of Sydney local government area spans 26km^2 (City of Sydney, 2017b, 2019a) within the Greater Sydney region of 12,368 km^2 (City of Sydney, 2017a). 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).[1] Despite the city's significance to Australia, the waste management system in Sydney is underrepresented in waste management literature. The case study in this thesis will contribute to this gap in the

[1] As a symbol, the City of Sydney local government is internationally significant, known for many Australian icons such as the Sydney Opera House, the Sydney Harbour Bridge, and the Royal Botanic Garden.

literature while providing insights that can inform waste reduction targets in other global cities.

'Zero waste' as a concept was understood as a boundary object in this research and was followed throughout Chapters Three and Four in the endeavor to understand the waste management system.[2] To investigate this city case study, the research initially set out to replicate the work Zaman and Lehmann (2013b) and Zaman (2014b) by conducting a holistic material flow analysis of the waste management system. In attempting to conduct this work, large gaps and inconstancies in public reporting on the case study city's waste managmnet sysem were observed. Consequently, the required information to conduct a material flow analysis following Zaman and Lehmann (2013b) and Zaman (2014b) was unavailable. Instead, Chapter Three featured a desktop review that gathered the information that was available about the waste management system from public reporting. Observed were three challenges to implementing and measuring the case study target: 1) poor communication of the target by the City of Sydney; 2) conflicting and incomplete public reporting of waste data by the City of Sydney; and 3) an absence of public reporting of waste data by other key stakeholders. Previous work that argues for holistic approaches to waste management assessment has focused on material flow analysis (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b). While

[2] A boundary object is a conceptual or physical item that people interact with while having both shared and differing understandings of the shared item (Ewenstein and Whyte, 2009; Star and Griesemer, 1989). Communication tacks back and forth between the communities of practice using the object in a manner that does not require consensus (Star, 2010), and in some cases, leads to systemic failure (Zuzul, 2019). The title 'boundary object' describes the object's behaviour as it crosses boundaries of understanding between the two groups during interactions (Star, 2010). Boundary objects are discussed in greater depth later in this thesis; see Section 4.3.11.

material flow analysis can capture information about progress towards a waste reduction target, it does not acknowledge or include social system mapping that highlights factors influencing system change (and, therefore, material flow). Chapter Four addressed this gap by investigating the social interactions and perception of zero waste that shapes system change in the city case study using stakeholder interviews and focus groups. Observed were fourteen factors that were distilled into six factor categories impacting the waste reduction target in the city case study: 1) financing; 2) pivotal events; 3) communication; 4) physical surroundings; 5) leadership; and 6) local government employment.

This chapter begins by introducing the research conducted for this thesis. Firstly, it outlines the objectives of the thesis and the meta-research question. Secondly, it presents the core motivations for conducting this research. Thirdly, it describes the research approaches and design that guided the thesis process. Fourthly, it summarises the key findings that emerged from this research. Fifthly, the contributions that the thesis makes to knowledge and society are discussed. Finally, the structure of the thesis is summarised.

1.1 Research Objectives

Rapid growth of waste production from cities is a threat to health, safety, and life on earth. Plastics and other toxic substances escape our control systems, resulting in pollution and other damage to environmental ecosystems. Increasing manufacture of goods with short life spans intended for disposal consumes finite resources while releasing their own harmful by-products. International and domestic long-distance movements of these goods for consumption contribute to greenhouse gas (GHG) emissions and wastes. Consumption and disposal form a cyclical cycle

that threatens sustainable futures on earth (Meadows et al., 2013; WCED, 1987). Sustainable development (or 'environmental sustainability') demands a balance between an ecological system with limited resources and an economic subsystem (Figge et al., 2023); it is not intended to sustain unfettered economic growth (Goodland, 1995). This research actively addresses this excessive and expanding pattern of waste by understanding the impact and processes of city waste reduction targets. Knowledge on how city waste reduction targets are planned, implemented, measured, communicated, and understood can support more effective system change to reduce waste in cities across the world.

The main objective of this research is therefore to observe and understand an active city waste management system undergoing a waste reduction target. The meta-research question is "What does system change in city waste management look like when undergoing a waste reduction target?". Two subsequent objectives aim:

- To explore and describe an active city waste management system undergoing a waste reduction target; see Chapter Three.

- To explore and describe key factors that may impact an active city waste management system undergoing a waste reduction target; see Chapter Four.

1.2 Research Motivations

The motivation for the thesis is driven by the disproportionate waste production of cities, which is not yet being resolved by waste reduction targets, and the limited number of studies that use a holistic approach to understanding city waste management systems. Cities are large contributors to the global waste crisis that is associated with dense and growing populations (Hoornweg et al., 2013; Lamb et al., 2018; MacArthur et al., 2016; Nwachukwu et al., 2017; Plata-Díaz et al., 2014; Sharpe and Giurco, 2018; Zaman and Lehmann, 2011a; Zaman and

Lehmann, 2013b). Despite this, no city has ever fully resolved its waste contributions. While a holistic approach to waste reduction targets that acknowledges the dynamic nature of all waste management levels and streams has been explored (Seadon, 2010), recommended (Zaman and Lehmann, 2011a), and grown in use over time (Zaman, 2015), there are few tools to support navigation and mapping of these targets. A notable exception is the performance measurement tool created by Zaman and Lehmann (2013b) called the Zero Waste Index. However, the Zero Waste Index is specific to zero waste and not transferable to other waste reduction target types. A holistic approach to navigating and mapping waste management systems that can be replicated across different waste reduction target types can equip government, industry, and academia to better execute and evaluate future waste reduction targets.

There are limited examples of studies that apply a holistic approach to understanding city waste management systems. Of those studies, there are even fewer examples that include an Australian case study (Zaman, 2015). Domestic research exploring holistic approaches to waste management system assessment, such as Zaman and Lehmann (2013b) and Zaman (2014b) in Adelaide, provide an important precedent for extending waste reduction measurements past weight-based metrics (to include factors such as substituted virgin materials, energy, greenhouse gas (GHG) emissions, and water. These seminal works extend the waste reduction measurement practices in the fields of accounting and economics to more holistically assess material flows, however they do not include the social systems mapping required when human factors are at play (Ackoff, 1994). Understanding the dynamics of social systems in the context of city waste management assessment can provide richer insights into change and therefore inform a more sustainable future. This thesis therefore seeks to support those sustainable futures by better understanding city waste reduction targets to inform more efficient processes that interrupt the cycle of consumption and waste that prevents environmental sustainability (Goodland, 1995).

1.3 Research Approaches and Design

Research approaches applied in this thesis were selected to address the meta-research question "What does system change in city waste management look like when undergoing a waste reduction target?" in the city case study (the City of Sydney and its 2030 zero waste target).

A transdisciplinary philosophical perspective was applied to this thesis where multiple disciplinarity practices (e.g., methods, disciplinary traditions, and topics) were combined across Chapters Three and Four of this thesis to provide a multifaceted and nuanced perspective of a waste management system as a city case study. The research uses the methodology of participatory action and includes a systematic inductive approach to data analysis. Participatory action research (PAR) in this thesis features the co-creation of knowledge between participants and researchers; where both contribute to the research discussion and data analysis. This was guided by the three differentiating characteristics proposed by Kemmis et al. (2013): 1) shared construction and ownership of research including both participants and researchers; 2) community analysis of a social problem space; and 3) a focus on community action. Systematic induction was the primary analytical approach; where emergent data, themes, concepts, dimensions and literature are reviewed iteratively to theorise the observed phenomena (Gioia et al., 2013). This was conducted using first and second order analysis of data: the first order analysis in this process identified terms, codes and categories in the participant's own language, while the second order analysis reflected on the codes drawn from the participants' perspectives and framed by theoretical considerations.

Data collection and analysis methods applied to this thesis were interwoven. These included a desktop review, semi-structured interviews and focus groups. The interwoven nature of data collection and analysis enabled the researcher to reflect upon findings at each stage in the research (including revisiting previously collected data and emergent insights). Findings from the desktop review are presented in Chapter Three, while findings from the semi-structured

interviews and focus groups are presented in Chapter Four. For further detail on the thesis research design including methodologies, ethical considerations and data storage, see Chapter Two.

1.4 Key Findings

This thesis set out to investigate how change in city waste management systems towards waste reduction targets can be improved. To address this, an Australian city with an ambitious city waste reduction target was used as a case study to meet the two objectives of this thesis. The case study explores a current waste reduction target being implemented in a metropolitan city local government area; zero waste by 2030 in the City of Sydney. To know something, we must know what it is not. This observation, supported by the work of Wittgenstein (1922) and Bowker and Star (1999), captures the unexpected outcomes of this research.[3] [4] Chapters Three and Four of this thesis observe what is absent from the waste management system in the city case study to provide a silhouette of what it is – inefficient.

Chapter Three addresses the first objective of the thesis by exploring and describing an active city waste management system undergoing a waste reduction target. Three key challenges in implementing and measuring the case study target were observed: 1) poor communication of the target by the City of Sydney; 2) conflicting and incomplete publicly reported waste data by

[3] Wittgenstein (1922) writes about the 'inexpressible' that will show itself [Proposition 6.522], where, when one is discussing that which cannot be spoken, one should be silent [Proposition 7]. Here Wittgenstein touches on the limitations of language to communicate, and one's capacity for knowledge. Grayling (2001) goes so as far as to argue that Wittgenstein here describes a 'showing' rather than 'telling' as the only possible communication form; Grayling uses a fictional second half of the work, *Tractatus Logico-Philosophicus*, that identifies the truly significant issues through its very silence on those topics.

[4] Bowker and Star (1999, p. 20) describe the unknown used for sense making in the context of communication, stating that "We know what something is by contrast with what it is not.".

the City of Sydney; and 3) an absence of publicly reported waste data by other key stakeholders. Foundational knowledge of the city case study provided by the holistic assessment of the waste management system in Chapter Three informed the objective and execution of the research in Chapter Four.

Chapter Four addresses the second objective of the thesis by exploring and describing key factors that may impact an active city waste management system undergoing a waste reduction target. In the knowledge sharing from participants, fourteen factors that were distilled into six factor categories were observed impacting change in the city waste management system towards its zero waste target: 1) financing; 2) pivotal events; 3) communication; 4) physical surroundings; 5) leadership; and 6) local government employment. These factors, identified through social systems mapping, were not observed in publicly reported information about the city waste reduction target in Chapter Three. This chapter therefore builds upon the city case study waste management system introduced in Chapter Three by contributing social system mapping.

1.5 Contributions of the Research

Contributions to knowledge in this thesis are provided through the Chapters Three and Four, which extend research into holistic assessment of city waste management systems, following researchers Zaman and Lehmann.

Chapter Three of this thesis extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) by reviewing communication and public reporting as factors in a city waste management system attempting a waste reduction target. The City of Sydney local government area and its 2030 zero waste target is used as a case study. Holistic approaches to waste management assessment that adopt a systems perspective have been recommended in the extant literature (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b) to improve understanding of waste management

systems. Zaman and Lehmann (2011a) claim that holistic systems approaches are required to provide a rich understanding of a dynamic city waste system and thereby achieve high impact in city waste reduction targets. Despite this, there are limited examples of city waste reduction targets that have adopted a systems approach (Zaman, 2015). A review of zero waste literature over a 19-year period (1995-2014) only identified 96 relevant papers (Zaman, 2015). Of these papers, only eight included an Australian case study (from three main authors), yet none of these included a holistic study of the waste management system in Sydney, the most populated city in Australia.

Chapter Three contributes to this gap by taking a holistic approach to assessing the waste management system in the city case study regarding its waste reduction target: the City of Sydney and its 2030 zero waste target. Holistic assessment is conducted in this chapter by reviewing parts in the system (such as communication and public reporting) and their interconnected relationships, in addition to traditional waste diversion metrics used by the City of Sydney. In doing so, it is the first holistic study of an active waste management system in Sydney.

Chapter Four of this thesis extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) by contributing social systems mapping to the analysis of reporting and accountability of government waste management explored in the previous Chapter Three. Ackoff (1994) discusses three types of systems (mechanical, organismic, and social), arguing that systems with human actors cannot be understood well without adopting a social systems perspective. A social system as a whole operates towards a purpose; however, some parts in the system also have their own purpose and the system resides within other systems (i.e. nested) that have purposes of their own (e.g. societies) (Ackoff, 1994). In this framing, human actors are 'parts' in the system and it is therefore vital to draw knowledge from those data sources in addition to looking at material flows when assessing a waste management system holistically. Despite this, previous research that argues for holistic approaches to waste management assessment (Hannon and Zaman, 2018;

Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b) rely on material flow analysis and do not include a social systems approach.[5] Seadon (2010) argues that a systems approach to waste management considers the relationship between all management levels and waste streams. Human actors are crucial to any waste management system, being both the producers and the managers of waste in a cyclical pattern of behaviours spanning over centuries. This chapter, therefore, argues that there is a gap in the extant waste management literature, and a need for holistic assessment of waste management systems that includes social systems mapping.

Chapter Four contributes to this gap by taking a holistic approach to assessing the city case study's waste management system that includes social system mapping through knowledge sharing from human actors in the systems (i.e. participatory action research) in relation to the City of Sydney and its 2030 zero waste target. Holistic assessment is conducted in this chapter by reviewing the way in which human actors in the waste management system understand and interact with the waste reduction target in the city case study. This process will highlight the limitations of environmental management reporting as an isolated approach to waste management assessment; demonstrating how a holistic approach that includes social systems mapping can contribute to a deeper understanding of a waste management system. This is the first holistic study of a city waste management system in Sydney, and the first such study of an active city waste management system in Australia that includes social system mapping. Additionally, the discussion of factors observed through the social system mapping of this

[5] The work of Zaman (2014b) might be suggested as an exception to this statement. In this paper, a survey of waste management organisations and experts was undertaken regarding motivations for zero waste activities and management priorities. This survey, however, was very limited in that it provided insight regarding material flows from participants, rather than seeking to understand the social drivers of the participants themselves in relation to zero waste. For example, it used multiple choice questions related to governance, policies and material flows without providing a space for dialogue regarding perceptions of the process of factors influencing change towards zero waste. The work of Zaman (2014b) is therefore not considered to have included a social system mapping approach.

chapter contributes to the limited study of factors influencing change in the context of city waste management system assessment.[6]

Together, Chapters Three and Four provide different perspectives on holistic assessment of waste management systems. When layered together, Chapter Three and Four create a conceptual model of the city case study and its waste reduction target; see Section 4.3. In this way, it contributes to extant literature regarding holistic approaches to waste management system assessment and addresses the limited presence of Sydney in this academic context. Additional outputs from this thesis include a conceptual model of change in the City of Sydney, and a set of navigation principles for understanding city waste reduction targets; see Section 4.3, and Section 5.2.2.

1.6 Thesis Structure

The structure of this thesis is as follows. Chapter One: Introduction provides an overview of how the thesis research addresses the meta-research question "What does system change in city waste management look like when undergoing a waste reduction target?" across Chapters Three and four of the thesis that together to form a city case study. This chapter outlines the core objectives, motivations, approaches, findings, contributions, and structure of the thesis.

Chapter Two: Research Design details the research questions, the methodology, data collection and analysis, ethical considerations and data storage. A transdisciplinary philosophical perspective shapes this thesis with a methodology of participatory action that uses a systematic

[6] Factors and related concepts influencing change have been discussed in the context of sustainable development (Gifford, 2011; Sorrell et al., 2011) or sustainable waste management systems (Brown and Bajada, 2018; Zaman, 2015).

inductive approach for data analysis. Data collection was conducted across a desktop review, semi-structured interviews and focus groups.

Chapter Three: Holistic City Waste Management System Assessment commences the case study that reviews the City of Sydney local government area and its 2030 zero waste target. Firstly, it outlines arguments from the extant literature for implementing holistic approaches to city waste reduction targets. It then summarises key contextual information on the City of Sydney as the case study for this chapter. Following this, zero waste is problematised as a unitary concept as informed by a desktop review undertaken of publicly available data on the city's 2030 zero waste target. Finally, a reflection on the findings and implications concludes this chapter with a discussion of study limitations and suggestions for further research that inform the study undertaken in Chapter Four.

Chapter Four: Social Systems in City Waste Management Assessment continues the case study that reviews the City of Sydney local government area and its 2030 zero waste target. Firstly, it explores the role of holistic approaches to assessing city waste reduction targets and the behaviour of factors that may impact changes towards such targets. Following this, zero waste is problematised as a waste reduction target in this city case study, as informed by semi-structured interviews and focus groups undertaken with stakeholders in the city's waste management system. Finally, a reflection on the findings and implications concludes this chapter with a discussion of study limitations and suggestions for further research.

Chapter Five: Conclusions and Implications provides a summary of the thesis findings, a conclusion (including study limitations), and a discussion of implications for future research. Following this, Appendices provide supplementary information for the thesis and References list the works consulted during the thesis.

Chapter 2: Research Design

This research combines several approaches from different traditions to address the meta-research question "What does system change in city waste management look like when undergoing a waste reduction target?". A transdisciplinary philosophical perspective shapes both the interpretation of the extant literature that drives the thesis, as well as the selection and application of the methodology and methods. The work uses the methodology of participatory action research and includes a systematic inductive approach to data analysis. Data collection and analysis are interwoven in this thesis across three methods: a desktop review, semi-structured interviews, and focus groups. Ethical considerations and data storage for this thesis were conducted in alignment with The Australian Code for the Responsible Conduct of Research and its Principles of Responsible Research Conduct, as adopted by the University of Technology, Sydney.

This chapter outlines the research design of this thesis across four sections: 1) research questions and aims; 2) transdisciplinarity as a philosophical perspective; 3) methodology (participant action research and a systematic inductive approach); 4) interwoven data collection and data analysis methods. The final sections discuss ethical considerations and data storage; and summarise the overall research design applied to this thesis.

2.1 Research Questions & Aims

The aim of this research is to understand a city waste management system that is transitioning to meet a waste reduction target. The meta-research question is: "What does system change in city waste management look like when undergoing a waste reduction target?"

Chapters Three and Four were undertaken to address this overarching meta-research question and objectives. Chapter Three was undertaken to address the first research objective: to explore and describe an active city waste management system undergoing a waste reduction target. Chapter Four was undertaken to address the second research objective: to explore and describe key factors that may impact an active city waste management system undergoing a waste reduction target.

2.2 Transdisciplinarity as a Philosophical Perspective

Transdisciplinarity was the philosophical perspective applied to this thesis, combining disciplinary practices (Dorst, 2018) across fields, traditions and faculties of knowledge. Boundaries between stakeholder groups such as academia, industry and government can be crossed through collaboration in transdisciplinarity (Zhongming et al., 2020). One of the key criticisms of the term transdisciplinary is the absence of a strict shared definition or common understanding across users (Mauser et al., 2013). While the debate between users and the frequent redefinitions of transdisciplinarity (Mauser et al., 2013) could be argued to keep the concept in circulation, it is commonly a source of confusion or misunderstanding between individuals. This thesis will therefore build on one definition of transdisciplinarity provided by Max-Neef (2005), as described in comparison with the associated terms disciplinary, multidisciplinary, pluridisciplinary, and interdisciplinary; see Figure 2.1.

'Disciplinary' refers to one single discipline being practised by an individual or group, for example, a physics professor or a science faculty who work independent of other fields. 'Multidisciplinary' refers to more than one discipline being practised by an individual or group without synthesis between these knowledges. For example, a researcher qualified in design and economics applies these knowledges for separate analysis of different parts of the same project without drawing links between them. 'Pluridisciplinary' refers to the cooperation between associated disciplines without coordination; whereby coordinating with another discipline facilitates a richer understanding of one's own discipline, as in, for example, disciplines of associated topics or of a common hierarchical level like history, sociology and language. 'Interdisciplinary' refers to the nesting of several disciplines within a single higher order discipline in a hierarchical manner, whereby a single discipline is viewed as defining the purpose of other disciplines.[7] This is argued to provide a sense of purpose for each of the nested disciplines. For example, when given a higher hierarchical order, agriculture can define the purpose of chemistry, soils, sociology and biology as disciplines.

In contrast to these four terms, 'transdisciplinary' refers to coordination between multiple disciplines across all hierarchies. In this way, disciplines may act as lenses through which to view or better understand other disciplines. For example, through design, one might learn about politics, mathematics and sociology. This transdisciplinary thesis enacts this behaviour in applying different disciplinary lenses (e.g. accounting, environmental science, and social science) to the topic of waste management in order to better understand an active waste management system.

[7] Max-Neef (2005) discusses the layering of this nested approach in a tiered pyramid format featuring four levels (or classifications) which appear in the following bottom-to-top order: 1) an empirical level, 2) a pragmatic level, 3) a normative level, and 4) a value level.

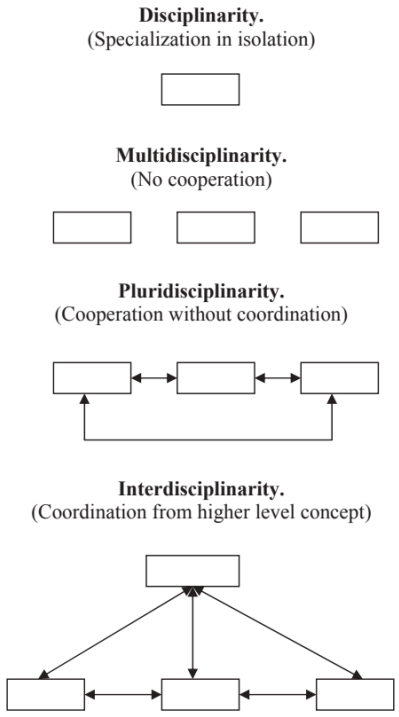

Figure 2.1. Differentiation between key terms regarding transdisciplinarity, sourced from Max-Neef (2005, p. 7)

Transdisciplinarity has been applied to this thesis to address the meta-research question "What does system change in city waste management look like when undergoing a waste reduction target?"; rich insights are provided using multiple disciplinary practices across the thesis. Thus, the methodology and methods of this thesis are framed by a transdisciplinary perspective; see Table 2.1. In utilising a combination of methodologies, methods, disciplinary traditions, and topics across Chapters Three and Four of this thesis, a multifaceted and nuanced city waste management system as a case study was developed. Two different qualitative methodologies are applied to this thesis: participatory action research and a systematic inductive approach. Three different methods are combined to align with these methodologies: a desktop review, semi-structured interviews and focus groups. The disciplinary traditions that inform these methods include social science, accounting and environmental science. These methodologies, methods and disciplinary traditions are all applied to the topics of: 1) waste

management and waste reduction targets; 2) holism and system dynamics; 3) factors in system change; and 4) language and communication.

Transdisciplinarity as a philosophical perspective was applied to this thesis to provide richer understanding of a waste management system than any one disciplinary practice could alone. For example, relying on an accounting perspective alone inhibits the ability to capture experiences of unique individuals who experience and drive change within the system context under study. In turn, a purely social science perspective would not provide the clarity of financial and political constraints that drive change in the system provided by an accounting perspective.

Table 2.1. Elements of the research design

Philosophical Perspective	- Transdisciplinary
Methodology	- Participatory action research - A systematic inductive approach
Method	- A desktop review - Semi-structured interviews - Focus groups

Together, the findings from Chapters Three and Four present a transdisciplinary and holistic case study featuring the City of Sydney's waste management system. This was addressed through the inclusion of different data source types across the chapters using participatory action research and a systematic inductive approach: 1) quantitative and qualitative data from publicly available documents reporting on the city waste management system; and 2) qualitative data from relevant system stakeholders during interviews and focus groups on factors impacting the waste reduction target. The inclusion of different data sources using participatory action research and a systematic inductive approach share characteristics with a mixed method approach. For example: 1) the intergradation of qualitative and quantitative data to provide mixed insights and foster novel insights (Creswell, 2014; Poth, 2018; Yin, 2011), 2) the strengthened credibility of findings where a method can compensate for weaknesses in another (Creswell, 2014; Silverman,

2010; Yin, 2011), and 3) fostering of collaboration between fields, traditions and researchers (Poth, 2018; Yin, 2011). The use of participatory action research and a systematic inductive approach contributes more than a mixed method approach alone could provide through: 1) an explicit ethical lens that places emphasis on community co-creation of the research including ownership, analysis and action (Kemmis et al., 2013), and an emphasis on observation with iterative reflection and continued re-analysis of collected data to minimise the impact if prior knowledge in the perception of findings. Collectively, these approaches push past the limitations of a mixed method approach to work directly (and respectfully) with those being studied as equal partners and to learn through continued self-critical reflection. While a mixed method approach focuses on how to best extract data for strong research validity, participatory action research and a systematic inductive approach provide guidance for how to interact with and for sources of data.

Implementing a participatory action research approach with a systematic induction approach for data collection and analysis supports the transdisciplinary scope of this thesis. These approaches also respond to the need for holistic approaches to waste management identified by Zaman and Lehmann (2011a), and the need to considering the relationship between all waste management levels and streams (including interaction of parts, dynamic processes, and emergent properties) identified by Seadon (2010). Transdisciplinarity is further enacted through this thesis by coordination between multiple disciplines across all hierarchies, following Max-Neef (2005). Perspectives and traditions from accounting, environmental science, and social sciences are included to support rich reflection and analysis of findings.

2.3 Methodology

The methodology of this thesis was constructed using participatory action research as an overarching approach that includes a systematic inductive approach as the primary analytical

approach. This section outlines both approaches and how they were applied in this thesis. Included in this section is a typology of participatory action research characteristics resulting from a desktop review of extant literature to inform the application of this approach, see Table 2.2.

2.3.1 Participatory Action Research

Participatory action research is a type of action research that was applied in this thesis. Action research is an approach known for valuing the instigation of change throughout the process of conducting a study. Participatory action research places emphasis on the relationship between participants and researchers as partners in joint knowledge creation around a research project. This methodology was chosen due to its alignment with a social constructionist[8] world view as well as its ability to help researcher and participant alike to co-create realities and foster communication across communities of practice. The action research spiral in this methodology, which includes loops of planning, acting, observing and reflecting (Kemmis et al., 2013), will also help address the research meta-research with qualitative rigor; see Figure 2.2.

Over time, the role of researchers has evolved from servicing society with knowledge generation and sharing to accommodating engagement with change-orientated activities (Wittmayer and Schäpke, 2014). Farrelly and Tucker (2014) argue that action research foundationally acknowledges that information sharing alone (as per traditional academic roles of knowledge generation) is insufficient in supporting environmental behaviour change. While many variations of action research have emerged in different fields, traditions and disciplines, they share these two features described by Kemmis et al. (2013): 1) recognising individuals as

[8] Simply explained, social constructionism is a world view that explores the manner in which individuals construct their perceived reality and understand or experience it uniquely (i.e. there is no one shared reality across society).

participants in the research process, and 2) orientation towards improving practices in the context of participants. Therefore, the emphasis is on both knowledge generation, and application leading to action or change in a given system. Action research facilitates learning across disciplinary knowledges and methods using the action research spiral (loops of planning, acting, observing and reflecting) (Kemmis et al., 2013) that aligns with the transdisciplinary charge of this thesis.

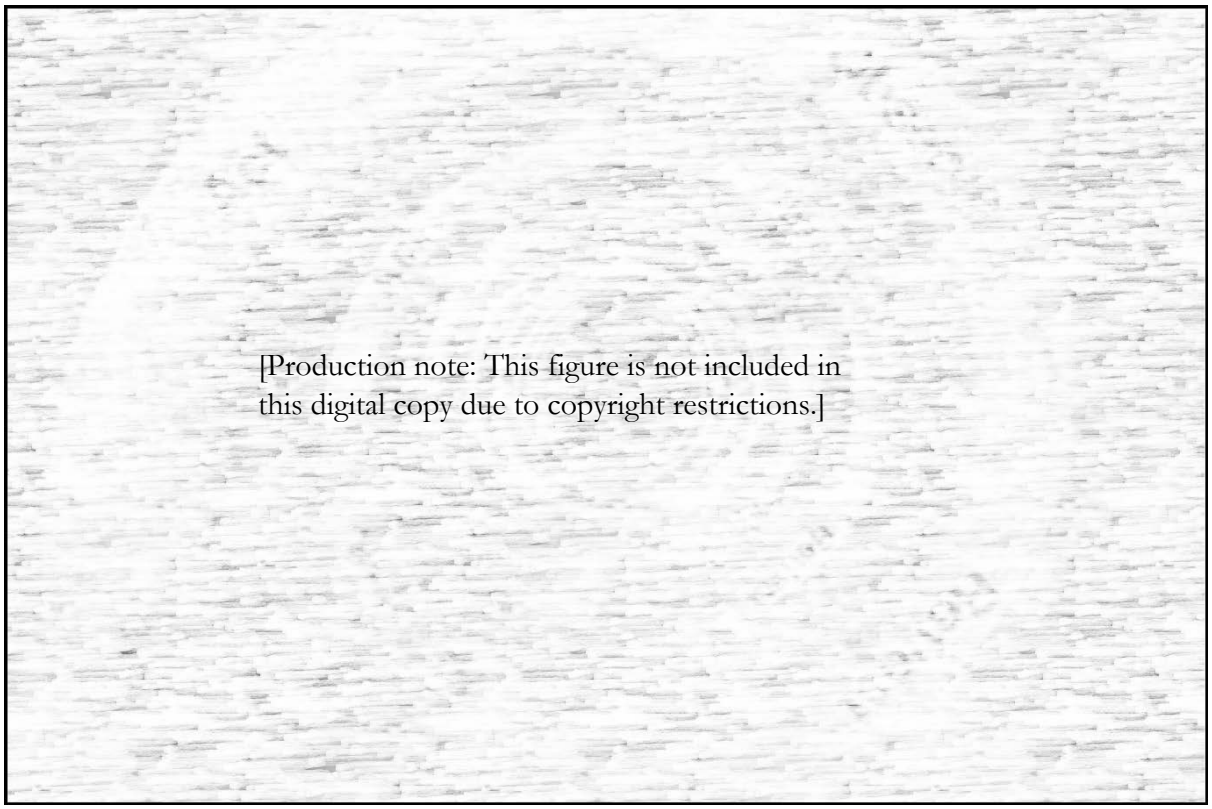

Figure 2.2. The 'action research spiral', sourced from Kemmis et al. (2013, p. 19)

Kemmis et al. (2013) argues that there are three characteristics that differentiate participatory action research from other methods: 1) shared construction and ownership of research including both participants and researchers; 2) community analysis of a social problem space; and 3) a focus on community action. In a review of the extant literature on the application of participatory action research, a typology of characteristics for researchers looking to apply the approach was not observed. Accordingly, a desktop review of participatory action research

literature was conducted to develop such a typology to support its application in this thesis and to provide a resource for future research; see Table 2.2. This table synthesises sub-characteristics that the ideal participatory action research approach should include, as aligned with the three differentiating characteristics of participatory action research following Kemmis et al. (2013): Shared research ownership, community analysis, and community action. Sub-characteristics included here were those observed in the literature to have an impact on the application of participatory action research in practice. These include both sub-characteristics that align with participatory action research and those that align with action research (the boarder approach in which participatory action research sits). The typology of characteristics and sub-characteristics included here reflect an ideal application of participatory action research in practice; however, a research project does not need to action all characteristics to be described as a participatory action research study. As a participatory action research approach heavily emphasises relationships between the researcher and the community under study, limitations in bias are foregrounded. These are discussed throughout relevant sections of the typology presented below (e.g., in the sub-characteristics of role reversal and reciprocity).

Table 2.2. A typology of participatory action research characteristics

Characteristics of Participatory Action Research	**Sub-Characteristics of Participatory Action Research**	**References**
Shared research ownership	Legitimacy perception	(Kemmis, 2006)
	Role reversal	(Argyris and Schön, 1989; Baum et al., 2006; Kemmis, 2006)
	Reciprocity	(Baum et al., 2006; Burgess, 2006; Maiter et al., 2008;)
	Multiple perspectives	(Argyris and Schön, 1989; Kemmis et al., 2013; Maiter et al., 2008)
	Freedom of choice	(Argyris and Schön, 1989; Baum et al., 2006; Kemmis, 2006; Kemmis et al., 2013)
Community analysis	Social justice	(Kemmis, 2006; Kemmis et al., 2013)
	Community lead	(Burgess, 2006; Kemmis, 2006)
	Evaluation of holistic factors	(Kemmis, 2006; Kemmis et al., 2013)
	Provisional understanding and agreement	(Kemmis, 2006)
	Problematising	(Kemmis, 2006; Kemmis et al., 2013)
	Civility	(Kemmis, 2006; Maiter et al., 2008)
Community action	Telling unwelcome truths	(Argyris and Schön, 1989; Kemmis, 2006)
	Critically justified	(Argyris and Schön, 1989; Burgess, 2006; Kemmis, 2006; Kemmis et al., 2013)

2.3.1.1 Shared Research Ownership

Shared research ownership features five sub-characteristics that researchers should strive to achieve, maintain or include in practicing participatory action research: 1) legitimacy perception; 2) role reversal; 3) reciprocity; 4) multiple perspectives; and 5) freedom of choice. Firstly, a perceived lack of legitimacy in circumstances, policies or decisions, as viewed by

participants, commonly acts as a catalyst for the forming of these communities of inquiry (Kemmis, 2006). Should this be observed in the analysis of data in this research thesis, the banding together of people referred to as 'solidarity' can generate a sense of power in the outputs of an action research project (Kemmis, 2006).

Secondly, participatory action research can enable a role reversal (Argyris and Schön, 1989; Baum et al., 2006) where "participants are the researchers" and "researchers are the participants" (Kemmis, 2006, p. 471). This kind of relationship aligns with the social constructionism model and may shift a historic association between knowledge and power (Baum et al., 2006). An active reflection on power dynamics between the researcher and participants is vital in this instance to provide safety for all involved. Tools and processes such as ethics documentation and transparency of any conflicts of interest can support this process; as can a transparent conversation of any imbalance of power or agenda that might be present before the research takes place. For example, the selection of participants for a study can be influenced by the researcher's prior perception of who should be invited into the research community. That potential conflict of interest was addressed in this thesis where participants were invited based on their own self-disclosure of topical relevance to the project (e.g., the use of specific terms in a person's job descriptions on LinkedIn) and representation across three different sectors (industry, government, or academia) for diverse perspectives, see Sections 2.4.2.2 and 2.4.3.2.

Thirdly, reciprocity in participatory action research can be illuminating, where individuals share in negotiation and learning (Maiter et al., 2008); fostering a common identity for the community of inquiry and recognise knowledge in others (Burgess, 2006). Here, negotiation of understanding may act as an instance of boundary crossing (Akkerman and Bakker, 2011; Star, 2010). During this process, one must reflect on reciprocity in relationships where an unbalance exchange might foster the emergence of power dynamics that could impact the research. For instance, if one person were to offer more than another that was perceived as a debt or obligation for allegiance.

Fourthly, valuing of multiple perspectives will be prioritised in the research, as a core part of participatory action research includes the acknowledgement of barriers one may feel towards sharing or participating in a participatory action research setting. This includes the acknowledgement of any factors impacting a participant's ability to share (Maiter et al., 2008). For instance, confidentiality and respect are directly addressed during semi-structured interviews and focus groups conducted. The need for multiple perspectives to include different perspectives in the research was addressed through the invitation and inclusion of participants from different sectors and positions, see Tables 2.3 and 2.4. The participant sample provides representatives from all three sectors, however those in industry outweigh those in other sectors. While participants of different role levels were invited to participate, there is a large representation of those in mid-level roles (such as managers, small business owners, consultants, and researchers).[9]

Finally, freedom of choice regarding participation and participation modes such as speaking, listening, observing or leaving (Baum et al., 2006; Kemmis, 2006) is valued in participatory action research.

Table 2.3. Sectors and Roles of People Invited to Participate in Semi-Structured Interviews and Focus Groups

Job Role	**No Sector**	**Government Sector**	**Industry Sector**	**Academic Sector**	**Total**
Manager		5	15	1	21
Researcher				8	8
Small Business Owner			7		7
Executive		1	4		5
Consultant			4		4
Community Leader	3				3
CEO			2		2
Minister (MP)		2			2

[9] Notably, no community leaders, ministers (MP), customer service, or mayors accepted invitations to participate.

Student				2	2
Board Member			1		1
Councilor		1			1
Customer Service			1		1
Mayor		1			1
Producer (TV)			1		1
Secretary			1		1
Total	3	10	36	11	60

Table 2.4. Sectors and Roles of People the Participate Sample in Semi-Structured Interviews and Focus Groups

Job Role	**No Sector**	**Government Sector**	**Industry Sector**	**Academic Sector**	**Total**
Manager		3	7		10
Small Business Owner			5		5
Consultant			4		4
Researcher				4	4
Executive			2		2
Student				2	2
Board Member			1		1
CEO			1		1
Councilor		1			1
Producer (TV)			1		1
Secretary			1		1
Community Leader	0				0
Minister (MP)		0			0
Customer Service			0		0
Mayor		0			0
Total	0	4	22	6	32

Shared research ownership as a characteristic of participatory action research was applied in this thesis through five sub-characteristics: 1) legitimacy perception; 2) role reversal; 3) reciprocity; 4) multiple perspectives; and 5) freedom of choice. Legitimacy perception was addressed in this thesis through the inclusion of participants in interviews and focus groups who worked with Australian waste management or zero waste in Sydney. This criterion for participant inclusion led to the collection of individuals from different professions, backgrounds and organisations who had experienced similar frustrations (factors of system change) with the progress towards waste reduction targets in their context. Many of those who participated discussed an observed lack of legitimacy in waste reduction targets, supporting waste management systems, and in particular, government policy or authority. During focus groups, this acted as an organic mechanism for banding participants together in solidarity through shared experience or opinion, despite disagreement in other aspects of discussed materials.

Role reversal was addressed in this thesis through the social constructionist worldview, whereby researchers and participants co-create knowledge, and therefore realities together. This was promoted through the flexible data collection design of semi-structured interviews and focus groups that facilitated emergent discussion of unprompted material by participants with the researcher, or in the case of focus groups, between participants. Additionally, this was supported by directly asking participants at the end of every interview if they had any additional comments on the topic that they had not been directly asked and would like to be included in the research. A systematic inductive approach to data collection and analysis will be discussed in Section 2.3.2 of this chapter. This facilitated role reversal whereby observations discussed by participants were included for reflection not only at each step of the data collection, shaping the research design iteratively, but insights were analysed and applied back to previously collected data. For example, after an insight shared by a participant halfway through the interview process that was suspected as a potential theme, the researcher would re-review previous interview transcripts for evidence

of the suspected theme as well as observing or explicitly asking about said theme in the next interviews.

Reciprocity was addressed in this thesis through the exchange of knowledge between participants during focus groups, which fosters a sense of community between individuals, and respect for the contributions of others in that community. The focus groups provided a meeting point for key stakeholders of Australian waste management or zero waste in Sydney, giving them the opportunity to engage and share with individuals they might not otherwise have spoken to. Prompting questions further supported this exchange of understanding and knowledge between participants. When participants became engaged in deep discussion with each other relating to a relevant topic, the researcher would commonly remain silent and allow this space for open collaborative discussion. As stakeholders in the system under study, each participant will receive a copy of the final research thesis to support change in their respective contexts. It is important to discuss the tensions of research co-ownership under the limitations of a PhD research where the researcher is being formally assessed on the work. Equitable co-ownership of research is less achievable in this context where institutional barriers require the researcher to maintain more authority on the project than is desirable for this kind of research. In future research that implements a participatory action research approach during a course of study, such as a PhD or Masters program, might consider asking participants what they would like to take away from their role in the research and attempt to negotiate through those requests (where reasonable). Alternative outputs for participants might include summaries, letters of participation, or diagrams of key learnings.

Multiple perspectives were addressed in this thesis through the inclusion of participants by relevance to a given topic area, rather than by a specific work or personal background. This facilitated a more diverse representation of opinion, experience and understanding across the participant sampling than was likely to be achieved through alternative sampling approaches. While questions to identify diversity were not explicitly asked during the semi-structured

interviews or focus groups, it became apparent throughout the data collection that participants represented a variety of: 1) cultural backgrounds and nationalities; 2) educational levels and backgrounds (i.e. high school, TAFE and/or university); 3) roles across industry, government or academia; and 4) residential locations (i.e. rural, city, inter-state) and personality traits (e.g. outspoken, reserved, open-minded). This diversity strengthens discussion by exploring the topics from broader perspectives in a manner that can both support and challenge proposed change, whereby participants learn both from and with each other (as well as the researcher).

Freedom of choice was addressed in this thesis through the ethical considerations of the thesis; at multiple points in the research, participants had opportunities to have control over their own participation. The ability to decline participation in the research was outlined in writing both in the invitation email sent to participants and the attached information sheet, which clearly stated that there was no obligation to be involved: "Participation in this study is voluntary. It is completely up to you whether or not you decide to take part." Within the information sheet clear language stated that participants were able to withdraw from the research at any point: "If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason…". This message was further supported when the researcher asked each participant, "Are you still comfortable if we record this [interview/focus group]?" before proceeding to record the discussion. In further support of this consent-driven approach to research, the researcher actively observed participants to notice if they did not want to engage with a question or prompt. They were not pressured to answer the question, and there was space for the discussion to move on. For example, one participant in the focus groups became heated towards the discussed topic and began raising their voice to other participants. To provide a safe space for participants to continue sharing, the research defused the situation by recognising the insights of those who had been speaking and introducing a new topic for the discussion to move on with.

Freedom of choice regarding engagement mode was limited, due to the online nature that the data collection took mid-way through the interviews in response to the Covid-19 pandemic (phone or Zoom calls). This resulted in the use of more verbal communication than writing, drawing or body language. During focus groups, a Miro board and Jamboard were presented as digital platforms where participants could draw or write in response to provided materials. Visual communication through the video of Zoom allowed for some body language communication between participants and with the researcher. This supported those participants who wished to observe or take a moment to consider rather than having to constantly participate in the active discussion.

2.3.1.2 Community Analysis

Community analysis features six sub-characteristics that researchers should strive to achieve, maintain or include in practising participatory action research: 1) social justice; 2) community lead; 3) evaluation of holistic factors; 4) provisional understanding and agreement; 5) problematising; and 6) civility. Firstly, (Kemmis et al., 2013), participatory action research is fundamentally social, conducted with the purpose of 'bettering' society (Kemmis, 2006). Here it is valuable to note the dual definition of 'action' in action research and participatory action research represents both: 1) action in the interaction with a community for research purposes; and 2) action of initiating change in the observed system through the method and with the results. This study aims to both contribute to knowledge and to inform change towards a more sustainable future for cities and society as a whole. Kemmis describes this eloquently in adapting the work of Borda (1979): "'investigate reality in order to transform it' and transform reality in order to investigate it" (Kemmis, 2006, p. 470).

In this way, investigation and transformation of reality through research is cyclical. The framing of social justice in this tradition assumes an understanding of agreed ethical or moral perspectives to which our society should abide. While it is clearly articulated in the literature that

participatory action research should be applied with the intended purpose of social justice, it is unclear how this purpose is to be measured or deemed appropriate. Use of this characteristic should therefore be considered critically with a clear discussion of how and why a society might benefit from the applied use of participatory action research.

Secondly, community involvement is key to action research (in which participatory action research sits), rather than solitary investigation. This includes community education, action and participation (Kemmis, 2006). This allows the researcher to be exposed to information contextually relevant to any discussions and action in participatory action research that can only be obtained intersubjectively through interaction with relevant community members (Kemmis, 2006). Challenges in determining who is the relevant community for a participatory action research study may begin early in the research process (Burgess, 2006). For this reason, clear inclusion criteria relating to the research topic and geography was introduced during participant recruitment for the interviews and focus groups, see Section 2.4.2.2 and Section 2.4.3.2.

Thirdly, the evaluation of varying, holistic factors such as social, cultural, discursive and materials (Kemmis, 2006) places emphasis on the 'particular' details and factors (Kemmis et al., 2013) whereby researchers strive to understand smaller areas of a system with richness. Caution is advised for researchers who intend to apply action research for the purpose of individual or localised reflection rather than an assessment of holistic factors (Kemmis, 2006).

Fourthly, due to the nature of intersubjectivity in communication as well as participatory action research, understanding and agreement must be acknowledged as 'situated' and 'provisional' (Kemmis, 2006) to the specific context in time; as aligned with a systems thinking approach which acknowledges unique and ever-changing states (Seadon, 2010). Therefore, participatory action research could be considered as either incomplete, ephemeral or ever-evolving. The scientific world can be understood as an abstraction from our experiences of uncertainty, ambiguity and idiosynchronicity (Baum et al., 2006). This could be likened to

looking through a stained-glass window and seeing part of the world through an ordered lens of understanding.

Fifthly, in treating topics or themes as problematic, relationships between people, things, ideas or discussions can be fostered (Kemmis, 2006).

Finally, while difficult to achieve, civility in communication during participatory action research can be valuable in achieving intersubjective agreement (Kemmis, 2006) and should be fostered using project resources, including time (Maiter et al., 2008).

Community analysis was applied in this thesis through the six sub-characteristics listed above. Social justice was addressed in this thesis through the very research topic itself – city waste reduction targets. This topic impacts the health and wellbeing of our environment as well as our human population and through this lens can be viewed as a social justice topic. This framing of social justice is subjective and applied here the researcher's perspective on the import and impact of the topic, as supported by participants during data collection. Engagement with this topic with the motivation to better society included both engagement with a community of practice for research purposes (this thesis) and initiating change in the observed system. Initiating change was addressed in this thesis in two ways; 1) engaging and educating participants to inspire them in their work; and 2) sharing the final thesis back to participants. These two actions were designed to support participants to drive change regarding city waste reduction targets in their own contexts.

Community-led research was addressed through the inclusion of participants from diverse backgrounds in the research as well as any other individuals the researcher may have interacted within in conducting the research (e.g. supervisors and academic or industry peers). In this way, the thesis was developed within a community of practice and therefore shaped by the context of the researcher. Throughout this process, questions, prompts or insights shared by the individuals around the research shaped and formed the research itself as well as the researcher and how they

viewed the research. Like the system around the topic, the research grew and changed throughout the generation of this work, which in turn shaped the final thesis produced.

Evaluation of holistic factors was addressed through the Chapter Four, which explores change in the topic under study; city waste reduction targets. Data collected during the semi-structured interviews and focus groups were used to identify factors of change in a case study context; the City of Sydney 2030 zero waste target. The scope of the research design allows for an exploration of specific details in a local government area to look at a city system experiencing transition. This was broad enough to understand change with detail without focusing too locally (i.e. studying one office) and compromising the generalisability of results or replicability of approach.

Provisional understanding and agreement was addressed in this thesis through the acknowledgement of ephemeral knowledge, whereby insights gained throughout the research (including those expressed by participants) are situational to time and place and are not necessarily applicable infinitely in the future, nor out of that context. For example, an insight gained from a participant during interviews would be shared at a specific point in time by a unique individual with their own personal or organisational agendas and context. To consider that insight in isolation of these factors would limit the ability for the research to reflect the system under study, thus inhibiting understanding and change. This acknowledgment of provisional understanding and agreement aligns with the systems thinking approach taken in this thesis, following Seadon (2010), whereby transdisciplinary work is inherently holistic.

Provisional understanding and agreement are also addressed in this thesis in terms of the application of learning and replicability of methodology. Findings in this thesis are inextricably linked with the city case study undertaken. Therefore, learnings from these findings as understood outside of this context need to be review critically to ensure the phenomena does in fact exist in another context (i.e., without making assumptions of all cities). Replicability of the methodology is possible where flexibility for a new context is accommodated. For example,

while a researcher might apply the methodology to a different city context, the very method itself, which requires iterative reflection and action, will be embodied uniquely upon replication.

Problematising was addressed in this thesis through the thesis topic of city waste reduction targets, where over-production of waste is a challenge or problem that is being addressed through the research. The inherent framing of this research provides a discussion space as well as a foundation for a community of practice between participants and the researcher in navigating this topic.

Civility was addressed in this thesis through the researcher's manner of communication with participants, and in mediation of discussions between participants during focus groups. Firstly, the researcher strove to speak to all participants in a calm, polite and professional manner. This included being restrained in voicing disagreement where participants discussed topics that the participant disagreed with, or when personally insulted. For example, one interview participant (PN12) passionately outlined their dislike of university education and younger people in their industry who do not share their experiences: "at universities they don't know how to teach you". The same participant directly targeted these comments, using the researcher as an example, with statements such as "you haven't had the experience of the world," and stating that the researcher should work for them driving a truck for six months, because "it'd be good for you". A myriad of other insulting or questionable comments were made during this interview (such as making assumptions about the researcher's family background) which were treated calmly and respectfully by the researcher without complaint, to facilitate a discussion surrounding the research topic. Another example of content the researcher disagreed with and was insulted by was in conversation with a different participant (PN14). This participant talked about women as being comfortable with change compared to men, because they experience transition from "a small girl to being a young woman, to being a, to being a mother, to being an older person," while men "find change really intimidating"; this was suggested as the reason for resistance to recycling programs. Comments like these from the

participant made generalisations about gender roles in the waste management industry and diminished the presence of women in the industry (i.e., implying that only men worked in the industry). As a woman who disagreed with these statements, the researcher again handled comments such as these with respect, acknowledging the participant's opinion without engaging in debate that would inhibit the research progress towards addressing the area of study.

2.3.1.3 Community Action

Community action features two sub-characteristics that researchers should strive to achieve, maintain or include in practising participatory action research: 1) telling unwelcome truths; and 2) critical justification of positions held. Firstly, action research is charged with the responsibility to tell unwelcome truths including results or discussions that may be considered uncomfortable and therefore require courage and conviction (Kemmis, 2006). Characteristics of participatory action research such as role reversal, multiple perspectives and community leads supported a respectful and open community of inquiry during the research when dealing with unwelcome truths (or perceived truths). Argyris and Schön (1989) recognise that undiscussable topics commonly have undiscussable existences, which will be addressed in the thesis with the action research spiral (Kemmis et al., 2013). This includes loops of planning, acting, observing and reflecting (Kemmis et al., 2013) to best identify seemingly undiscussable topics for inclusion in the research project.

Secondly, effective action research (in which participatory action research sits) must be able to withstand crucial examination rather than conducted to implement an agenda (Kemmis, 2006). Another way of understanding this could be the concept of active open-mindedness which will be utilised using the systems thinking approach. A balance between rigor and relevance (Argyris and Schön, 1989), time commitment and value (Burgess, 2006) have been developed through the data collection process that actioned rounds of participatory action

research in this thesis. Testing alternative theories is recommended in participatory action research to reach a better understanding of the outcomes (Argyris and Schön, 1989).

Community action as a characteristic of participatory action research was applied in this thesis through two sub-characteristics: 1) telling unwelcome truths; and 2) critical justification. Telling unwelcome truths was addressed through providing a welcoming space where participants could feel free to share their opinions openly, even those they knew others would disagree with. For example, during interviews, some participants spoke both positively and critically about their industry, their organisation, the government or the general public. Some of these controversial conversation topics (e.g., the waste to energy debate) were evenly discussed by participants within focus groups for a wider discussion where they were more anonymous. Further, unwelcome truths were also addressed through the writing of this thesis, where data collected or the resulting analysis presented insights that some stakeholders may disagree with or have a negative response to. For example, Chapter Three of this thesis explored the city case study and identified that while the City of Sydney has good intentions regarding its waste reduction target, it performs poorly in regard to public reporting and measurable impact.

Critical justification of analysis was addressed in this thesis through the application of a systematic inductive approach to produce qualitative research with rigor. This facilitated explorative open-mindedness throughout a research design that allows for emergent discovery while being able to withstand critical refection as a thoughtfully constructed contribution to knowledge.

2.3.2 A Systematic Inductive Approach

Gioia et al. (2013) provides a precedent methodology for a systematic, rigorous inductive approach in qualitative research, which has been followed in this thesis. Gioia et al. (2013) strongly encourage originality in theorising and welcome innovation in the proposed

methodology, based on the premise that research method based solely on prior knowledge inherently delimits what can be known. This thesis accepts the invitation to innovate from a proposed approach throughout data collection and analysis, as influenced by action research and transdisciplinary approaches. For instance, in the approach proposed by Gioia et al. (2013), data is considered theoretically rather than solely methodologically; therefore, the researcher reviews emergent data, themes, concepts, dimensions and literature iteratively throughout the research design to theorise the observed phenomena. An iterative analysis of and between aspects of the research was conducted throughout this thesis in a more complex extension of the action research spiral, see Figure 2.2. Gioia et al. (2013) argue that the research process may transition from inductive to adductive in nature, which describes the nature of this thesis.

The approach outlined in Gioia et al. (2013) includes many features of inductive qualitative research that can be used in different combinations in respect to the unique research being conducted. One such feature outlined is that of first and second order analysis of data. First order analysis in this process identified terms, codes, and categories in the participant's own language (Gioia et al., 2013). It typically results in a myriad of categories without an overarching narrative that might appear overwhelming (Gioia et al., 2013). From this list of categories, the researcher searches for similarities and differences that culminate in fewer (grouped) categories and each of these categories receive a label and description (Gioia et al., 2013).

In second order analysis, the researcher reflects on the codes and categories identified and considers both the participants' perspectives and more abstract notions of theoretical consideration (i.e., reviewing for themes in the data both identified and unidentified by the participants). In this stage, the researcher questions the emergent themes identified and considers their theoretical contribution to understanding or describing the observed phenomena. This reflection values concepts previously unexplored in the literature (or existing concepts present in

a new context). From these second order themes, 'aggregate dimensions' are drawn (overarching trends in observations made).[10]

The systematic inductive approach in this thesis included the theoretical consideration of data (rather than solely methodologically) whereby emergent data, themes, concepts, dimensions and literature are reviewed iteratively to theorise the observed phenomena. This was conducted using first and second order analysis of data. The first order analysis in this process identified terms, codes and categories in the participant's own language, while in the second order analysis, the researcher reflected on the codes and categories identified (the participants' perspectives and theoretical considerations).

2.4 Interwoven Data Collection & Data Analysis Methods

Following a systematic inductive approach and the influences of participatory action research, data collection and data analysis were conducted in an interwoven manner. This included iterative evaluation between the collected data and theory, following Nicolini et al. (2012) to ensure emerging observations were supported by both.

Iterative reflection on both new data and previously collected data was undertaken throughout the research process in a compounded manner; see Figure 2.3. Data collection begins with the desktop review (containing two rounds). Data collected from this method funnels into a data analysis stage for the desktop review. The final analysis from this stage informs the first round of semi-structured interviews (and therefore the data collected). Data collected from this method funnels into a data analysis stage for the semi-structured interviews and desktop review, whereby all previously collected data is re-analysed, following Gioia et al. (2013). This step was repeated for the second round of semi-structured interviews, then for the focus groups; see

[10] In this thesis, aggregate dimensions are represented in the three domains of change, see Section 4.3.1.

Figure 2.3. Finally, all previously collected data (from the desktop review, interviews, and focus groups) was re-analysed following Gioia et al. (2013). This final analysis forms the research findings of this thesis, which is discussed across Chapters Three and Four; the desktop review addressing the first research objective, while the semi-structured interviews and focus groups address the second research objective. Due to the interwoven nature of this research method, in this section, data collection and data analysis will be outlined together in a chronological fashion to best reflect the process undertaken.

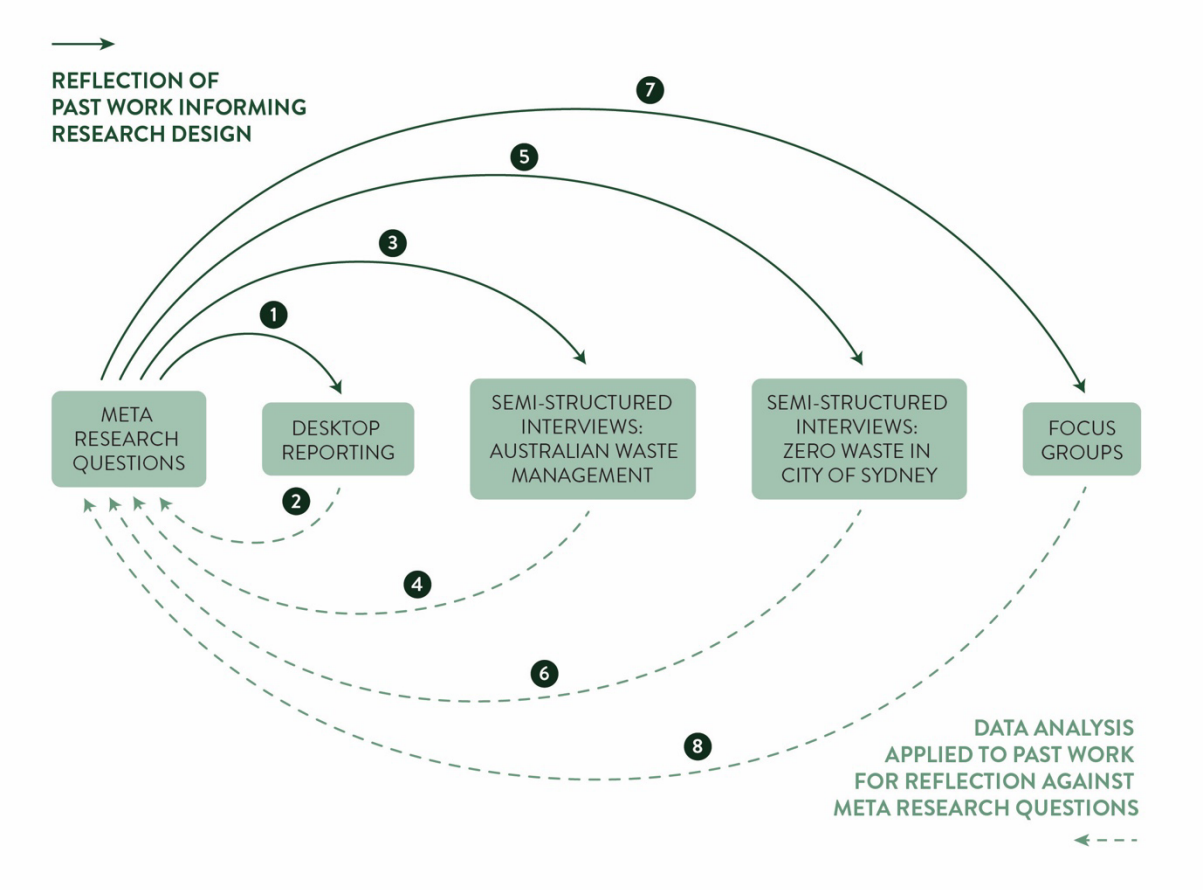

Figure 2.3. Interwoven data collection & data analysis methods

2.4.1 Desktop Review

2.4.1.1 Desktop Review Data Collection

Informed by the research meta-research, online research was conducted to better understand the waste management systems in Australia and Sydney that are studied in this thesis. Insights from this stage of data collection was used in Chapter Three of this thesis. A desktop review was selected as a data collection method for its ability to provide foundational knowledge on a topic space quickly, despite its limitations in biased privileging of sources (i.e. authors, publishers and formalised knowledges). Initially, the desktop review was designed to collect the reuired to data to conducting a holistic material flow analysis of the city case study's waste management system following Zaman and Lehmann (2013b) and Zaman (2014b). In attempting to conduct this work, large gaps and inconstancies in public reporting were observed and the information required to conduct the material flow analysis was unavailable. Instead, the desktop review was conducted to gather the information that was available about the waste management system from public reporting. Movement of waste, key stakeholders, financing and policy were all actively reviewed to better understand the city waste management system undergoing transition towards a 2030 zero waste target, whereby the resulting insights might inform change towards the waste reduction target.

2.4.1.2 Selection of Texts to Review

Following Gioia et al. (2013, p. 21), the desktop review here placed emphasis on relevance of data for revision over quality and is less extensive than traditional literature reviews, so as to create a 'semi-ignorance' that allows for emergent findings to be observed. As a result, 13 texts were reviewed in great detail, being iteratively reread several times to inform the Chapter Three of this thesis.

Firstly, exploratory scoping desk research of mixed media was conducted to better understand waste management systems and waste reduction targets internationally, domestically and in Sydney. This search aided in the identification of waste reduction target types such as zero waste that appeared dominantly in the reviewed materials (i.e. journal articles, new articles, press

conference transcriptions, policy documents, and waste reports). Observations made during this scoping desk research informed a focus on waste reduction targets, including zero waste as a key framework, and the City of Sydney as a case study city attempting a zero waste target during this research. Research questions were shaped accordingly from these observations and iterated over time throughout the research to best reflect the emergent findings; see Appendix A.

Secondly, a structured desktop review of publicly available data was conducted, as informed by the first research objective. This followed the scoping desktop review by pursuing the research questions that investigated zero waste in the City of Sydney local government area including: 1) how it is understood, measured and perceived by stakeholders; and 2) the public reporting documented plans, progress, budgeting and additional information that demonstrate progressing towards the target.

To identify potential texts for inclusion in the desktop review, the following Boolean search of Google was conducted on February 2, 2021: ('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'). As a result, a variety of text types were included in the review, such as academic journal publications and industry or government reports. Snowball sampling (Lecy and Beatty, 2012; Yin, 2011;) was then used, where texts from the Boolean search were reviewed. Relevant texts referenced within the work were then included in the research until saturation of content was reached (i.e., no new information was being provided by additional texts). This process produced the 13 texts that were used for Chapter Three. Of these, domestic government or commonwealth funded reports were dominant, primarily featuring information regarding: 1) population and demographics, 2) geography and boundaries, 3) policy and jurisdiction, or 4) waste production and waste management.

2.4.1.3 Desktop Review Data Analysis

Analysis of this data was conducted in three stages: 1) reading and collation, 2) visual system mapping, and 3) reflexive application of learning. Firstly, each text was read once to grasp the context of any core information, then a second time to identify key data points or learnings that culminated into themes that were iteratively developed (e.g., weight of waste being reported from different sectors in the city case study). Notes, figures and key data points were collated in tables and graphics that enabled findings generation throughout this process.

Secondly, visual system mapping was undertaken with the aim of observing any relationships between information in the documents not explicitly acknowledged.

Thirdly, reflexive application of learning was undertaken to provide richer understanding of the city case study and areas of focus. Analysis of this data is outlined in more depth in Chapter Three.

2.4.1.4 Desktop Review Findings Summary

This desktop review revealed the complicated and poorly communicated nature of the city case study's zero waste target, where there is a misalignment between the waste reduction target and characteristics of the system that it addresses. It also revealed incomplete and competing information in public reporting of waste-related information from the city (such as quantities, sources and locations). Finally, it highlighted an absence of information in public reporting from key stakeholders. For further detail on the findings of this desktop review, see Section 3.2. These insights informed the research design of the semi-structured interviews, then later, the focus groups, where the researcher iteratively reflected on the desktop review data and findings throughout the research.

2.4.2 Semi-Structured Interviews

2.4.2.1 Semi-Structured Interview Data Collection

Informed by the second objective of the thesis, semi-structured interviews were conducted to explore and discuss factors influencing change towards the City of Sydney's 2030 zero waste target. These semi-structured interviews were conducted to complement the desktop review by providing insights into the system from personal, individual perspectives that could not be provided through publicly available texts alone. Semi-structured interviews also provided flexibility to facilitate discussion on topics or observations suggested by participants which would otherwise not be addressed through pre-prepared questions (as a result of the inherent bias of the desktop review and prior knowledge of the researcher). The facilitation of participant input serves the role reversal sub-characteristic of participatory action research in this thesis, whereby the participant can become the researcher, and the researcher can become the participant during different stages of the research (Argyris and Schön, 1989; Baum et al., 2006; Kemmis, 2006). Insights from this stage of data collection were used in Chapter Four of this thesis.

2.4.2.2 Approach taken to Conducting the Semi-structured Interviews

To facilitate participants in sharing their personal experience and reality (as it pertains to the research topic), open-ended questions were proposed to small samples following Silverman (2010). Aligning with the systematic inductive approach proposed by Gioia et al. (2013), the researcher conducted these interviews, actively setting aside assumptions constructed by the researcher's personal bias (including those informed by extant literature). This consideration was recommended by Gioia et al. (2013) in order to support participants as 'knowledgeable agents' to provide their account of reality (e.g. using their terms, not those from the literature or our own understanding).

There was a total of 24 semi-structured interviews with 26 participants conducted over two rounds; see Table 2.5. The two rounds each explored a key theme: 1) waste management in Australia, and 2) zero waste in the City of Sydney. Participants were stakeholders in industry, government or academia whose work directly related to Australian waste management or zero

waste in the City of Sydney local government area. For example, those who used 'waste management' or 'zero waste' in their job descriptions on LinkedIn, or who were listed under a relevant organisation's website as working with 'waste management' or 'zero waste'.

The semi-structured interviews were first conducted and audio recorded in person. They were converted to phone interviews early in the data collection phase in response to the Covid-19 pandemic (aligning with the government's health advice at the time of data collection). Transcription of these semi-structured interviews was conducted by two external service providers.[11] These transcripts were then verified for accuracy; the researcher listened to the audio recording while reading the transcription and manually editing the text where required.

Table 2.5. Semi-structured interview stages, numbers, and participants

Interview Rounds	**Interview Number (IN)**	**Participant Number (PN)**
Australian waste management	IN01	PN01
	IN02	PN02, PN03
	IN03	PN04
	IN04	PN05
	IN05	PN06
	IN06	PN07
	IN07	PN08
	IN08	PN09, PN10
	IN09	PN11
Zero waste in the City of Sydney	IN01	PN12
	IN02	PN13
	IN03	PN14
	IN04	PN15
	IN05	PN16
	IN06	PN17
	IN07	PN18
	IN08	PN19
	IN09	PN20
	IN10	PN21

[11] Rev and Transcription Australia were hired to transcribe the interview recordings.

	IN11	PN22
	IN12	PN23
	IN13	PN24
	IN14	PN25
	IN15	PN26

2.4.2.3 Guiding Questions for the Semi-structured Interviews

In designing a systematic inductive approach in qualitative research with rigor that followed Gioia et al. (2013), these interviews were designed to directly address the research question without posing leading questions that may shape a participant's response. This included a set of guiding questions approved through the internal university ethics process. The semi-structured questions for the first round, addressing the theme of Australian waste management, included the following:

- Could you tell me a bit about yourself?
- What are your insights on the waste systems of cities/your city?
- What is your role in the waste management system of cities/your city?
- Where do you see change in the waste management system of cities/your city?
- Where do you think responsibility lies for change in the waste management system of cities/your city?
- Where do you feel the greatest contribution to change in the waste management systems is?
- What role do you think plastic has in the waste management system of cities/your city?
- What role do you think time-based goals play in the waste management system of cities/your city?
- Is there anything else that you feel would be relevant to this research and would like to discuss?
- Is there anyone you would recommend I include in this study?

The semi-structured questions for the second round addressing the theme of zero waste in the City of Sydney included the following:

- Could you tell me a bit about yourself?
- What is your role in zero waste?
- How would you describe zero waste?
- Do others share your view of zero waste?
- How do you measure zero waste?
- Are you already implementing a zero waste goal?
- Have you ever achieved zero waste?
- Do you think zero waste is achievable?
- What/who is helpful in your zero waste work?
- What/who is not helpful in your zero waste work?
- Who do you think is responsible for zero waste?
- How would you describe the relationship between the terms 'zero waste' and 'circular economy'?
- Is there anything else that you feel would be relevant to this research and would like to discuss?
- Is there anyone you would recommend I include in this study?

As guiding questions, these prompts provided space, not only for participants to discuss their perspective on aspects of the system that the researcher might not have known to directly ask about, but also provided flexibility for the researcher to respond iteratively between each interview. For instance, questions prompting rich and passionate responses (e.g. regarding the achievability of zero waste) could be prioritised in the ongoing interviews, whereas questions that were not yielding constructive answers in addressing the research questions (e.g. regarding the responsibility for zero waste, or tools and frameworks used by participants in zero waste work)

could be de-prioritised or excluded from future interviews. Alternatively, where a participant had sufficiently addressed a question in a previous answer, that question would be excluded for expedience. For example, many participants addressed the question regarding the relationship between zero waste and circular economy before they had been directly asked about it.

2.4.2.4 Variation in the Semi-structured Interviews Guiding Questions

There were two types of variations to the guiding questions. The first were additional clarifying questions following topics participants had raised. For example, when a participant (PN17) noted that they felt the public was understanding the difference between reuse and recycling, the researcher asked the prompting question "Do you know if there's a reason for that?". This resulted in the participant (PN17) outlining a series of big shifts in the public's understanding; the first being the television show War on Waste (Downes et al., 2019), the second being increased concern about climate change prompted by the bush fires, and the third being the visible recovery of nature in response to isolation during start of the Covid-19 pandemic (e.g., the Venice canals).

The second type of variation to the guiding questions followed Gioia et al. (2013), where interpretive research requires flexibility in interview questions throughout the data collection process to respond to iterative discovery (i.e., to explore concepts emerging from the data collection process). For example, the researcher began asking some participants (PN 06, 14, 20) if they or others in their industry had experienced burn out in relation to their work, after one participant (PN07), unprompted, shared their account of the "psychological cost" of their work:

> "Well, I have found myself, um, close to burning out because I was still focused on trying to – to be zero waste. […] That it was quite draining and emotionally stressful because of the lack of systems being in place around you to make it work. […] So it was sort of feeling that you facing

> into vault instantly and you're fighting, you're swimming upstream." (PN07)

Participants were asked about burn-out after describing their work with a sense of urgency, or tragic events as societal pivot points for change (e.g., PN 14 discussed 149 deaths in Manila after the 2011 cyclone caused by plastic bags blocking drainage in the slum, causing people to drown). While one participant answered yes when describing both individual and community burn out, the others dismissed the enquiry with responses like "Uh, I think everybody does a little bit from time to time" (PN14), or, "Uhm, no. I guess I'm lucky, you know, since that doing consulting, you do get a lot of variety?" (PN20). After receiving unfruitful responses to this emergent line of enquiry, the researcher stopped asking about experiences of burn-out. This demonstrates the way in which iterative discovery can be tested throughout the data collection process, where an emergent theme was directly discussed with participants to understand any potential role it may have in addressing the research question.

This process of altering variations to the guiding questions with iterative discovery following Gioia et al. (2013) excluded questions that did not prompt responses that addressed the research question. For example, the researcher stopped asking about the tools, resources or models participants used to think about zero waste after receiving the answer 'no' (PN16, 17) or vague and unhelpful descriptions of practice that included no tools, resources or models (PN14, 21).

> "I haven't done, um... haven't used any models, haven't used any tools, haven't, uh, delved into it in any kind of, um, analytical systemic way apart from just using it as an aspirational thing. So, so I haven't, I haven't used them." (PN16)

"Um, not really actually (laughs). Um, we're not that scientific. I mean the reality of [organisation name redacted], what we're really good at is communications and running (laughs) a really good marketing campaign that gets people doing something." (PN17)

"Most of the things we've done um, most of the things that we've tried to do have been community focused. So, most things have sort of been built from the ground up really, depending on the community. And you do have to change, you do have to change things in certain communities to make it work, and to work more appropriately. For example, with, if you're collecting organic waste in Australia, you generally collect organic, you generally collect yard waste with food waste, 'cause it makes sense, if we're trying to make a compost." (PN14)

"Uhm, yeah, yeah. We – we've, we use tools with evidence and research by others probably more than tools and such. Ahh, we develop tools internally. Uhm, and, you know, there's, there's – there are the organisations that – that have tools, but yeah, we – we use consultants, we use – yeah, some tools that they developed. We develop our own tools and, uhm, again, yeah, things that – that we can do that – that creates consistency across reporting..." (PN21)

2.4.2.5 Semi-Structured Interview Data Analysis

Informed by the second objective of the thesis, coding was conducted to identify factors influencing change towards the City of Sydney's 2030 zero waste target. The researcher analysed data using both structured coding and free coding, referred to as first order and second order

coding, in a systematic inductive approach following Gioia et al. (2013). This thematic coding was applied to transcripts of the semi-structured interviews on coding software called NVivo which facilitates tagging of quotes under nested themes for categorisation, review and correlation between themes.

The coding process began with a small, structured coding set of overarching observations made by the researcher after conducting the semi-structured interviews and having listened to the recordings again to verify the accuracy of transcripts (e.g., achievability and definitions of zero waste). This initial set of codes was applied to the first few interviews whilst engaging with free coding, where interesting trends or observations would be grouped under new theme codes in Nvivo (e.g. change factors such as financial, social and political drivers, or pivotal events such as the bush fires, China Sword and Covid-19). The researcher would then reflect on changes occurring to the coding set and re-order or label codes to better reflect the structure of themes being observed (e.g., communication factors and semantics regarding how participants talk about waste that were initially considered under the theme 'change factors' and were given their own section under a new theme, 'language'). Numerous rounds of this combined structured coding and free coding were undertaken until the researcher felt the codes best reflected the observed patterns communicated by the interviewed participants. This approach was guided by Gioia et al. (2013) who argued that researchers conducting inductive qualitative research can identify emergent patterns in the data that participants themselves may be unaware of; in doing so, constructing theoretical concepts for consideration. The final set of thematic codes generated through this data analysis process were curated into a table that was presented to the second round of focus groups for discussion and validation through a feedback process; see Section 2.4.3.

2.4.2.6 Semi-Structured Interviews Findings

This series of semi-structured interview revealed factors influencing change in the system towards the waste reduction target of the city case study. For further detail on the findings, see Chapter Four. These insights informed the research design of the focus groups, and the re-analysis of the desktop review where the researcher iteratively reflected on the interview data and findings throughout the research.

2.4.3 Focus Groups

2.4.3.1 Focus Group Data Collection

Informed by the second objective of the thesis, two rounds of focus groups were conducted to explore and discuss factors influencing change towards the City of Sydney's 2030 zero waste target. These focus groups were conducted to build upon emergent themes in the semi-structured interview data by processing observations through group analysis. This aligned with the community analysis characteristic of participatory action research, see Section 2.3.1.2. Focus groups provided an opportunity for stakeholders in the waste management system in the City of Sydney from different fields, disciplines and organisations to interact. These interactions included prompts from the researcher who facilitated the focus groups and open-ended questions that supported participants to discuss concepts together and eventually form an ephemeral community of practice. This space provided an opportunity for individuals who otherwise would not have met each other (or have time and space for deep conversations) to gather and consider as a community key concepts in their context in a shared waste management system. Insights from this stage of data collection were used in Chapter Four of this thesis.

2.4.3.2 Approach to Conducting the Focus Groups

To support participants to discuss their perspectives, experiences and understandings of zero waste with each other in a group environment, the two rounds of focus groups featured prompts developed from observations in previously collected data. These were communicated

both visually and verbally (with the ability to respond in writing or verbally) to engaged participants with different learning strengths as well as catering to different levels of comfort in the fostered social setting. This approach aligns with the freedom of choice sub-characteristics of participatory action research by proving different modes for participants to engage with the research, see Section 2.3.1.1.

There were three focus groups with a total of 14 participants (three-to-five participants per focus group) that ran over two rounds of discussion (i.e., different prompts); see Table 2.6. The two rounds each explored one key theme following observations from the semi-structured interviews: zero waste in the City of Sydney, and emergent research themes. Participants were stakeholders in industry, government or academia whose work directly related to zero waste in the City of Sydney local government area. For example, those who used 'zero waste' in their job descriptions on LinkedIn, or who were listed under a relevant organisation's website as working with 'zero waste'.

The focus groups were first conducted over video conferencing software called 'Zoom' in response to the Covid-19 pandemic (aligning with the government's health advice at the time of data collection). Both video and audio recordings were taken during these focus group calls using the embedded recording function of Zoom. Transcription of these focus groups was conducted by an external service provider.[12] These transcripts were then verified for accuracy by the researcher listening to the audio recording while reading the transcription and manually editing the text where required.

[12] Rev and Transcription Australia were hired to transcribe the interview recordings.

Table 2.6. Focus group stages, numbers, and participants

Focus Group Stages	**Focus Group Number (FN)**	**Participant Number (PN)**
Zero waste in the City of Sydney	FN01	PN14
		PN25
		PN26
		PN27
		PN28
	FN02	PN13
		PN29
		PN30
		PN31
	FN03	PN06
		PN19
		PN23
		PN32
		PN33
Emergent research themes	FN01	PN14
		PN25
		PN28
	FN02	PN30
		PN13
		PN29
		PN30
	FN03	PN06
		PN32

2.4.3.3 Focus Group Guiding Prompts

Prompts in the two rounds of focus groups focused on two themes observed in previously collected data: 1) zero waste in the City of Sydney, and 2) emergent research themes.

Prompts in round one of the focus groups (zero waste in the City of Sydney) included a discussion of key language used in relation to zero waste in the City of Sydney during the semi-structured interviews. Participants were asked about different language and frameworks associated with waste reduction targets to better understand how they perceive and use these tools in their work. Questions in this round included the following:

- How do you explain your sustainability goals to others in your industry or field?
- How do you explain your sustainability goals to others outside your industry or field?
- Do any of these zero waste definitions resonate with you? 1) Is a goal to aim for; 2) Is 90% landfill diversion; and 3) Is recycling everything.
- Do any of these circular economy definitions resonate with you? 1) Is the replacement term for zero waste, 2) Is a perspective, and zero waste is a goal, and 3) Is how to achieve zero waste.
- Do you recognise any of these frameworks? [Shown were the 6 diagrams showing waste reduction models with their heading and labels covered: Circular Economy by the Ellen MacArthur Foundation; The 5 Rs by Roadrunner; The Zero Waste Hierarchy 7.0 by the Zero Waste International Alliance; The Waste Hierarchy by the NSW EPA; Circular Economy Systems Diagram (commonly known as 'The Butterfly') by the Ellen MacArthur Foundation; and Circular Economy by Irisphere.]
- Do you USE any of these frameworks? [Shown were the same 6 diagrams from the previous question.]

Enquiries regarding tools, resources or models used by participants did not yield helpful responses during the semi-structured interviews; see Section 2.4.2. A question referring to frameworks used by the participants to understand waste reduction was reintroduced here, to either: 1) provide an opportunity for group discussion should peer communication prompt recollection of engagement with tools, resources or models; or 2) validate the lack of engagement

with tools, resources or models observed in the interviews. The discussion of frameworks in this round of focus groups demonstrated some familiarity with a few frameworks such as The Waste Hierarchy by the NSW EPA and the Circular Economy Systems Diagram by the Ellen MacArthur Foundation. Despite this, there were no clear examples of participants using these frameworks in their work, and the lack of engagement with tools, resources or models observed in the interviews was ultimately validated in this round of focus groups.

To facilitate these conversations over zoom, an online digital note-organising program called Jamboard was used to communicate prompts and provide a space for participants to visually respond as an alternative or accompaniment to their verbal discussions. A similar program, Miro, was the software initially selected for use in this round of focus groups; however participants struggled to log in and navigate Miro. After approximately 15 minutes of Miro use in the first focus group, the researcher swapped it for the back-up file made in Jamboard for collaborative discussion. Jamboard was then used for the rest of this round across the remaining two focus groups.

Prompts in round two of the focus groups (emergent research themes) included a discussion of emergent research themes that had been observed whilst analysing the data collected during the semi-structured interviews and the first round of focus groups. This featured a table of emergent themes (including main themes, sub-themes and their descriptions) developed in a Microsoft Word document that was presented to the participants for discussion using the screenshare function in Zoom. Participants were asked if the themes, sub-themes and descriptions resonated with their experience of the waste management system they worked in (i.e. zero waste in the City of Sydney).

After each discussion, the themes table was updated in response to participants' feedback to better reflect their understanding and perspective in the waste management system context in which they sat. The iteration process included relabelling, culling of themes or sub-themes they did not connect with, or altering descriptions to better reflect their experience of the waste

management system. This approach aligned with a social constructionist worldview and the foundational principal of participatory action research that acknowledges participants and researchers as co-creators of knowledge. The fifth and final table was then used for thematic coding of all previously collected data (from the semi-structured interviews and focus groups); see Section 4.2.

The validation of emergent findings from the semi-structured interviews during focus groups serves a function that aligns with a systematic inductive approach. In this approach, Gioia et al. (2013) propose an optional additional step where independent individuals can be invited to review and code the collected data to consider alternative interpretations of the observed phenomena. Here, the participants were presented with concepts, frameworks and themes collated from the interviews and focus groups that had been previously conducted, rather than reviewing the raw data in response to time limitations (given the vast length of transcripts).

2.4.3.4 Focus Group Data Analysis

Data analysis for the focus group data followed a similar approach to that undertaken in Section 2.4.2.5. Informed by the second thesis objective, coding was conducted to identify factors influencing change towards the City of Sydney's 2030 zero waste target. The researcher analysed data using both structured coding and free coding, referred to as first order and second order coding following the inductive approach of Gioia et al. (2013). This thematic coding was applied to transcripts of the focus group on coding software called NVivo which facilitates tagging of quotes under nested themes for categorisation, review and correlation between themes.

The coding process followed that developed during the data analysis for the semi-structured interviews, where the most recent structured coding set of overarching observations made would be applied to transcripts of the first round of focus groups. Data from the first round of focus groups was included in the iterative structured and free coding that was being

actioned on the semi-structured interview data at the time. The final set of thematic codes generated through this data analysis process were curated into a table that was presented to the second round of focus groups for discussion and validation through a feedback process; see Section 4.2.

After the second round of focus groups had been conducted, all data collected thus far in the thesis (including the desktop review, semi-structured interviews, and focus groups) were considered against the finalised thematic coding set verified through the second round of focus groups. This final thematic coding set was marginally altered in language (e.g., a title changed to be shorter or a better reflection of descriptions in quotes) but stayed relatively the same as that verified by participants during the second round of focus groups. Across all of the transcripts reviewed (both interviews and focus group content), there were 47 sub-themes identified and 1,700 quotes in total attributed across these themes; one theme had as many as 172 quotes for consideration.

A final table of eight themes and 47 sub-themes was developed after this data analysis and participant consultation; see Section 4.2. From this final table, six categories of fourteen factors were identified as impacting change in the city case study waste management system; see Section 4.2.1. These factors were distilled from the themes table by drawing out areas of discussion that were supported by: 1) discussion across multiple participants; and 2) a direct connection with the city waste reduction target being assessed. Those included were factors that held enough anecdotal evidence from multiple participants to support a discussion using multiple perspectives, rather than basing a discussion on the viewpoint of a sole participant and privileging information that might not represent the larger waste management system being studied. Excluded factors were those that did not provide sufficient anecdotal evidence for discussion (i.e., not enough account of the observation by participants or lack of clarity in the observation description by the participant). Additionally, factors deemed irrelevant to the research questions were also excluded (e.g., educational background of participants).

Additionally, in writing up the final factors for Chapter Four of this thesis, factors were reorganised into new categories to best communicate the remaining factors into similar groups (e.g., pivotal events).

2.4.3.5 Focus Group Findings

This series of focus groups revealed factors influencing change in the system towards the waste reduction target of the city case study, as identified alongside the semi-structured interviews. For further detail on the findings of these focus groups, see Chapter Four. These insights informed the re-analysis of the desktop review and semi-structured interviews, where the researcher iteratively reflected on the focus groups data and findings throughout the research.

2.5 Ethical Considerations and Data Storage

This research has been conducted to comply with *The Australian Code for the Responsible Conduct of Research* and its Principles of Responsible Research Conduct that have been adopted by the University of Technology Sydney: 1) honesty in the development, undertaking and reporting of research; 2) rigor in the development, undertaking and reporting of research; 3) transparency in declaring interests and reporting research methodology, data and findings; 4) fairness in the treatment of others; 5) respect for research participants, the wider community, animals and the environment; 6) recognition of the right of Aboriginal and Torres Strait Islander peoples to be engaged in research that affects or is of particular significance to them; 7) accountability for the development, undertaking and reporting of research; and 8) promotion of responsible research practices (NHMRC, 2018).

The ethics application submitted for approval to the UTS Human Research Ethics Committee (HREC) has been approved with amendments, including the use of virtual tools such as Zoom to hold focus groups as a result of Covid-19 restrictions. A HREC aligning research

design was developed in consultation with my primary supervisor (A/Prof Paul Brown), one of my co-supervisors (Dr Susanne Pratt) and UTS Ethics staff members (Brie Turner and Racheal Laugery).

Digital audio recordings of semi-structured interviews or focus groups were transcribed, de-identified, and stored under password protected devices and hard drive backups (or on secure UTS online cloud services and email accounts). Documentation of reflections or consent forms regarding semi-structured interviews and focus groups are digitally stored in the same manner, while physical copies are securely stored in a locked room or on the person of the researcher when in use.

2.6 Discussion and Conclusion

As outlined in this chapter, the transdisciplinary philosophical perspective applied to the thesis supports the combination of perspectives and methods of different traditions to achieve greater understanding of a topic than can be achieved by any one perspective alone. In this thesis, participatory action research and a systematic inductive approach (Gioia et al., 2013) both reside within this transdisciplinary perspective. Participatory action research is a type of action research that emphasises the relationship between participants and researchers as partners in joint knowledge creation, aligning with social constructionism. A systematic inductive approach for qualitative research with rigor iteratively incorporates the first and second order data analysis, following Gioia et al. (2013). Both participatory action research and a systematic inductive approach feature a process of iterative data collection and analysis. In participatory action research, this is referred to as the action research spiral, featuring loops of planning, acting, observing and reflecting (Kemmis et al., 2013). In a systematic inductive approach (Gioia et al., 2013), data analysis is similarly conducted along every step in the research design, which in turn drives inductive decision making in the next steps of the research design. However, it reflects

and re-analyses all data collected thus far at every stage (where participatory action research only reflects on the step most recently completed). This research design, therefore, combines these two approaches, participatory action research and a systematic inductive approach, to deliver qualitative research that both: 1) acknowledges participants and researchers as partners in joint knowledge creation; and 2) iteratively re-analyses all data collected at each data collection point to inductively inform the research design.

Chapter 3: Holistic City Waste Management System Assessment

3.1 Introduction

As a large growing city, Sydney needs help addressing waste production, as recognised by the 2030 zero waste goal put in place by the City of Sydney. In this chapter, the need for a holistic approach to waste management assessment will be outlined, building on extant literature and a case study featuring the City of Sydney's waste management system. This research will address the first objective of the thesis; to explore and describe an active city waste management system attempting a waste reduction target. In doing so, it will contribute the first holistic study of an active city waste management system in Sydney.

This chapter was initially intended to extend the work of Zaman and Lehmann (2013b) and Zaman (2014b) by conducting a holistic material flow analysis of the city waste management system to understand change towards a waste reduction target. The City of Sydney local government area and its 2030 zero waste target was selected as a case study. A desktop review was commenced to identify the data required to conduct an analysis of available publicly reported data on the waste management system. Large gaps and inconsistencies in public reporting were encountered, preventing a rigorous material flow analysis to be conducted. This observation aligned with the inconsistent reporting observed by (Qian et al., 2011) of waste management information from local governments in New South Wales. Instead of executing a material flow analysis, this chapter was reframed to showcase the information that was publicly available about the waste management system to

highlight gaps and inconsistencies in public reporting through an analysis of reporting and accountability of government waste management systems. Observed were three key challenges in implementing and measuring the case study target: 1) poor communication of the target by the City of Sydney; 2) conflicting and incomplete public reporting of waste data by the City of Sydney; and 3) an absence of publicly reported waste data by other key stakeholders.

3.1.1 City Waste Reduction Efforts and Assessment

As a society, we are dependent on a level of consumption and disposal that our systems have grown around. Like a tree that has grown through a fence, it is now inconceivable for the two parts to be separated and remain intact, yet both cannot fully fulfil their purpose. The tree, serving the purpose of growth and resource production within a natural ecosystem, represents the consumption organisms require to live. Meanwhile, the fence, serving the purpose of systematic division of space and control within a natural ecosystem, represents the human-led intervention of concentrated disposal. Twisted together, the tree struggles to thrive and produce resources for consumption (like the economy, rapidly exhausting earth's available resources), and the metal of the fence becomes warped under the pressure of excess mass it was not designed to hold (like waste management systems that struggle under the rising over-capacity of disposal).

Global waste production is rapidly growing, with daily waste expected to reach six million tonnes in 2025 (Hoornweg et al., 2013; Nwachukwu et al., 2017).[13] OECD countries with high urbanism and income, such as Australia, contribute almost half of the world's waste production

[13] Comparatively, daily global waste was 3.5 million tonnes in 2010 (Hoornweg et al., 2013; Nwachukwu et al., 2017).

(44% in 2012) (Hoornweg and Bhada-Tata, 2012). Housing 50% of the world's population (Hoornweg and Bhada-Tata, 2012), cities are key players in this global waste crisis. Disproportionally the largest contributors to waste production, they generate 70% of the world's waste while covering a mere 2% of its surface area (Zaman and Lehmann, 2013b). Consequently, many cities have implemented waste reduction targets such as zero waste (e.g. Adelaide, Auckland, New York, and San Francisco) or circular economy (e.g. Glasgow, Groningen, and Umeå). Others have made commitments like the C40 Advancing Towards Zero Waste Declaration (C40, 2019), which had 27 international cities, states and regions registered by 2019. These city waste reduction targets require reporting to communicate progress, and to collaborate with stakeholders in the system; for example, to inform policy change or incentive investment in the waste management industry.

These targets and commitments are typically reliant on diversion rates as a core metric of success in waste reduction, which is problematic in that it does not acknowledge other factors involved in the target (Zaman and Lehmann, 2013b). For example, the waste reduction target for the Australian state of South Australia (SA) is defined as "zero avoidable waste to landfill by 2030" with varying diversion rates for each main industry: 75% diversion for municipal solid waste, 90% diversion for commercial and industrial waste, and 95% diversion for construction and demolition waste (Green Industries, 2020). Key additional factors may include waste composition or source type, funding, or geographic considerations such as storage and transport. Assessment tools such as the Zero Waste Index (Zaman, 2014b; Zaman and Lehmann, 2013b), the Green City Index (Siemens, 2012; Venkatesh, 2014) and the Arcadis Sustainable Cities Index (Arcadis, 2022) have sought to include more of these factors when considering performance of waste management systems. Of these examples, the Zero Waste Index is the only one that is waste management specific; the Green City Index and the Arcadis Sustainable Cities Index include broader sustainable factors (e.g. environmental governance, buildings, transport and air quality). Additionally, the Zero Waste Index was produced through academia, while the Green

City Index and the Arcadis Sustainable Cities Index were written and produced by the engineering firms Siemens and Arcadis. However, while the Zero Waste Index does include substitution factors (virgin materials, energy, GHG emissions and water) outside of waste diversion to assess the waste management system (Zaman and Lehmann, 2013b), there are other key factors that can influence the performance of a city towards a waste reduction target.

Environmental management accounting is a relatively recent field to emerge toward the end of the 20th century in response to increasing concerns for ecological degradation facilitated through organisational structures of industry, government, and academia alike. This domain in part seeks to understand and improve accounting practices and standards that push for sustainable development and is therefore directly relevant to waste reduction target efforts. From that emerging tradition of environmental management accounting, waste management and other non-financial auditing processes have emerged to measure and understand the impacts of those organisations. For example, in a local government context, Lewis (2000) explores and proposes the use of 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 during the year 2020 from metals and mining companies in Australia. Similarly, Adler et al. (2022) previously reviewed solid and liquid waste disclosure reporting from the top 30 companies in Indian between 2012-2018 as measured by the Bombay Stock Exchange (BSE) benchmarking index called 'SENSEX'.

Despite this attention in environmental management accounting on non-financial auditing in a local government context (Lewis, 2000), and on waste management (Adler et al., 2022; Ha & Mansi, 2023), there is limited understanding that combines those features in the reporting of waste management in a local government context. The prolific emergence of waste reduction targets in local governments domestically and internationally relies on this work for accountability, transparency, and stakeholder collaboration towards these ambitious goals. An

exception to this gap in the literature is a study by Qian et al. (2011) that explores waste management reporting in local governments across New South Wales. The work explores the changing nature of environmental management accounting in the context of local government waste management. Qian et al. (2011) observed that levels of public reporting on waste management from the 12 local government case studies ranged widely; primarily 30%-60% of the required information available with one anomaly of 95%, and three others ranging from 5%-22%). This conflicts 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 Government, 2019). Target 7 states to "Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions" (Australian Government, 2019, p. 28)[14] While it is recognised by the federal government that reliable reporting on waste management is fundamental to informing change towards waste reduction in Australia, there remain inconsistencies in local government's ability to meet those reporting expectations.

Previous literature has raised the alarm having observed the steady encroachment of industry involvement in waste management practices that, over time, lessen the authority of government over waste management and impact the transparency of public reporting on waste flows. In reviewing the role of environmental audits in UK local governments, Lewis (2000) warned that auditable measurement systems might place more attention on performance towards those measures rather than towards sustainable development. Jones (2020) identified that unreliable and incomplete data was a vulnerability in Australian government public reporting on

[14] Targets 1-6 that preceded Target 7 are as follows: 1) "Ban on export of waste plastic, paper, glass and tyres, commencing in the second half of 2020", 2) "Reduce total waste generated in Australia by 10% per person by 2030", 3) "80% average resource recovery rate from all waste streams following the waste hierarchy by 2030", 4) "Significantly increase the use of recycled content by governments and industry", 5) "Phase out problematic and unnecessary plastics by 2025", and 6), "Halve the amount of organic waste sent to landfill for disposal by 2030" (Australian Government, 2019, p.6, 8, 12, 18, 22, 26).

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 these warnings, an analysis of reporting and accountability of government waste management systems in Australia remain relatively unexplored; where the one example identified (Qian et al., 2011) explored local governments from a state lens (NSW) lacking a focus on city waste management systems.

This research contributes to the tradition of environmental management accounting by exploring and describing an active city waste management system attempting a waste reduction target, paying attention to, *inter alia*, reporting and accountability. Chapter Three therefore extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) by reviewing communication and public reporting as factors in an active city waste management system attempting a waste reduction target. Section 1.1 will discuss the key concepts of waste, waste management, waste management systems and traditional waste management assessment practices that frame the contribution to knowledge made by this chapter.

3.1.1.1 Waste as Material Without Value

Waste is the surplus disposal of resources and a major by-product of the boom in consumerism which has snowballed since the 20th century. It is a tangible consequence of failures in our shared human history described by leading scholars as a symbol of inefficiency (Zaman and Lehmann, 2013b) and the result of inadequate thinking (Seadon, 2010). In traditional waste management practices, it is considered an 'end-of-life' product that is produced post-consumption (Zaman, 2014b).

In this thesis, the term 'waste' is used to describe any physical material that is perceived to contribute no value (economically, emotionally, or otherwise) to any stakeholder in the system under observation. This was informed by definitions of 'waste' in the extant literature that featured similar language pertaining to perceived value (typically as tailored to the industry or

topic area under analysis). For example, Zaman and Lehmann (2011a, p. 75) include the agreed understanding, "solid waste including any trash, garbage, refuse or abandoned materials which have 'no economic value' or functions for anybody". Additionally, Perey et al. (2018, p. 632) describe waste as "any nonvalue-added process or physical material occurring in business practices and services". In the literature, 'solid waste' can often be used to refer to physical waste items and reduce any misinterpretation of waste as a concept (e.g. a waste of time).

Waste material cannot be viewed as a single entity, nor a stable fixture. This material is moved across space and time in a practice referred to as waste management.

3.1.1.2 Waste Management as Material Flows

Waste management is the intentional movement of waste that is commonly referred to in the literature with the phrase 'material flows'. Over time, waste management practices evolved with human society to include waste treatment in addition to the movement of material flows. Zaman and Lehmann (2011a) describe this evolution using six waves of waste management innovation: 1) open dumping (which still occurs in low-income countries); 2) uncontrolled landfill (from 3000BC in Greece); 3) composting (from 2000BC in China); 4) recycling and controlled landfill (internationally fuelled by the great oil crisis in the 1970s); 5) waste-to-energy technologies; and 6) zero waste (a 21st century holistic approach). Figure 3.1 shows an example of material flows between stages of production and consumption in developed high-income countries that leads to different waste types. These are often divided into three categories: 1) municipal (i.e. local government level); 2) commercial and industrial; and 3) construction and demolition (which in Figure 3.1 has been included under 'industrial' waste).

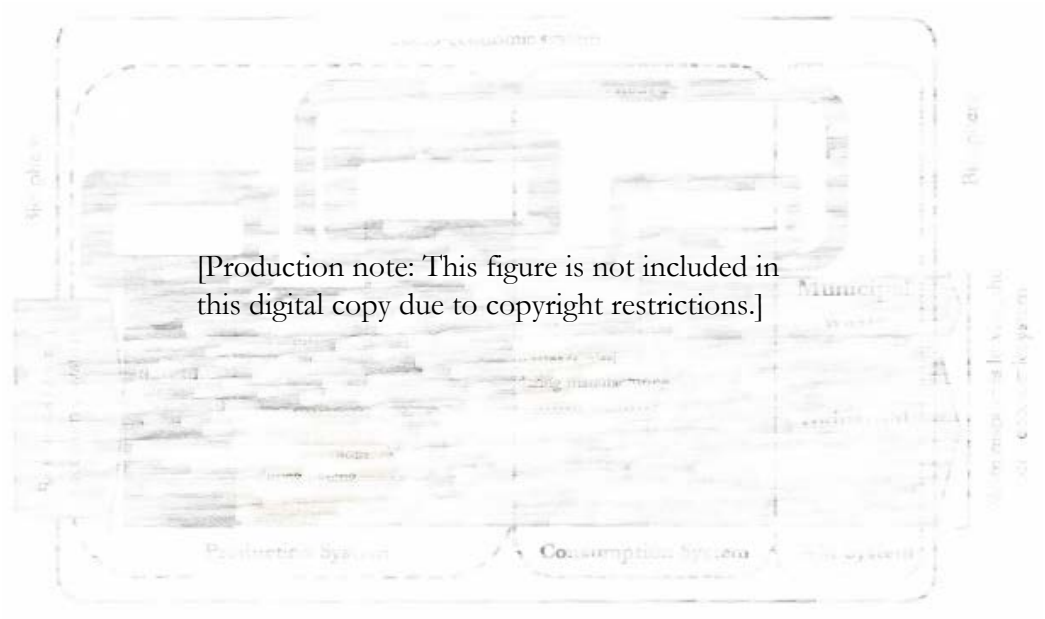

Figure 3.1. 'Wastes in our society', sourced from Singh et al. (2014, p. 801)

WM = waste management.

Since the 1960s and 1970s, environmental movements around the globe have brought more public attention to waste management. During this time, landfills began replacing opening dumping and waste burning (Singh et al., 2014). Wilson (2007) presents six drivers for waste management in a contemporary setting: 1) public health, 2) environmental protection, 3) resources value of waste, 4) closing the loop, 5) institutional and responsibility issues, and 6) public awareness. Contemporary waste management in high-income countries typically includes activities for waste treatment such as recycling, energy recovery and pre-treatment before disposal, and activities for waste prevention such as diverting waste from landfills (Singh et al., 2014). Described as 'end-of-pipe' solutions by Singh et al. (2014), many modern waste management approaches aim to address one of these societal drivers but lack recognition of overconsumption as exacerbating waste production. Zero waste or circular economy are two examples of contemporary holistic waste management approaches, described as 'cradle-to-cradle' or 'closed-loop' (Zaman and Lehmann, 2011a), that emphasise efficient resources to reduce (or eliminate) waste production.

The complex history of waste management is different in every country, although histories, examples and studies from high income Western countries dominate academic discussions. Viewing waste management as a system with unique parts (such as material flows, geography, stakeholders, policy or funding) can acknowledge these differences. For example, when six different zero waste targets in the same English government program were reviewed, it was observed that each target required unique communication aligning with the values of local residents (Phillips et al., 2011).

3.1.1.3 Waste Management Systems with Interconnected Moving Parts

As a phrase, 'waste management system' frames waste management that acknowledges complex moving parts and marking of boundaries. The term 'system' can be traced to systems thinking, described as a 'whole' with two or more parts Ackoff (1994).[15] These parts can affect the performance or properties of the whole (Ackoff, 1994). In the context of waste management, 'parts' refer to aspects such as material flows, geography, stakeholders, policy or funding, and the 'whole' refers to the waste management system. For instance, Zaman and Lehmann (2011a) describe waste management systems as having socio-economic, political, environmental, and technical aspects (i.e., parts) as well as acknowledging multiple stakeholders with roles across these aspects. Parts, or subgroups of parts, in a system cannot affect the whole independently (i.e., are always considered in connection with other parts or subgroups) (Ackoff, 1994). In a

[15] The term 'system' can be observed in different disciplinary and topical contexts. While derived from systems thinking, the term has been used by some as an interchangeable synonym with other concepts such as complexity and chaos theory, due to similar characteristics such as interconnectivity between parts, constant change (dynamic), and unpredictability of that change. A pop culture example includes chaos theory, which was briefly summarised by the character Dr Ian Malcolm in the 1992 classic film *Jurassic Park* to describe "unpredictability in complex systems" in Scene 38 at [00:45:00-00:46:40]. These are, however, separate concepts with their own nuanced differences. Systems, complexity and chaos are different theories. While it is important to recognise the common confusion between these concepts, the term system will be used here exclusively, following the use of waste management systems as a phrase in the extant literature.

waste management context, this means that parts such as material flows, geography, stakeholders, policy or funding are always considered as interconnected with each other and are therefore in a constant state of influence (i.e., change). It is therefore important to acknowledge any unknown or unmeasured parts in a waste management system (Seadon, 2010; Zaman, 2015) that might explain change in the system. For example, the wealth of a nation has been shown to have a direct and dramatic impact on the type of waste management in a city (Hoornweg and Bhada-Tata, 2012). The importance of identifying all parts of a system is supported by Seadon (2010) who describes a systems approach to waste management as inherently transdisciplinary with a central tenet of holism. Seadon (2010) argues that a systems approach to waste management considers the relationship between all management levels and waste streams; see Figure 3.2. Considering these relationships includes the interaction of parts, dynamic processes, and emergent properties (Seadon, 2010).

Therefore, while actions, objectives or context have been previously used to define city waste management (Delmonico et al., 2018; Seadon, 2010), a systems approach acknowledges the ephemeral nature of moving parts (i.e., constant change) that inextricably ties any assessment results to the location and time in which it was conducted. Traditional approaches to waste management assessment have been criticised for favouring waste diversion metrics without recognising or considering these parts and their interconnected relationships in the system, which fundamentally impact on change.

Disciplinarity	Multidisciplinarity	Pluridisciplinarity	Interdisciplinarity	Transdisciplinarity
Reductionist. Splitting into separate waste streams for management	*Reductionist.* Consider different waste streams without links	Cooperation but no coordination between waste stream management	Waste stream management coordinated from a higher level	*Systems.* Coordination of management between all levels and all waste streams

Figure 3.2. Waste management approaches, sourced from Seadon (2010, p. 1640)

3.1.1.4 Criticisms of Traditional Waste Management Assessment

Consumption-driven behaviours place pressure on cities to manage the waste being increasingly produced in a sustainable manner (Zaman and Lehmann, 2011a). Traditional methods for waste management have been criticised for their inefficiency or a failure to address the causes of growing waste production. The reliance of waste management system performance on waste diversion rate as a key metric has been criticised by (Zaman and Lehmann, 2013b) as inadequate and limited in forecasting ability (Zaman, 2014b). Seadon (2010) identifies seven areas in which those traditional practises fall short: 1) the vast efforts expended on collecting and analysing immaterial data that do not change waste management practices; 2) irreversible interventions without mechanisms for mitigating theses side effects; 3) short-term solutions based on goals that do not consider long-term sustainability; 4) underestimated time lags between an intervention and its effects that can be dismissed as a perceived lack of response; 5) undervaluing or disregarding intervention side effects; 6) focus on addressing individual problems without considering the waste management system as an interconnected whole; and 7) reliance on linear data extrapolations of short timelines that do not reflect a larger pattern of dynamics in a waste management system. As a result, holistic approaches to waste management assessment that adopt a systems perspective have been recommended (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b) to improve and better understand waste management systems and therefore inform change towards more sustainable practices. This chapter, therefore, extends the work of these authors by implementing a holistic approach to waste management system assessment in relation to a city waste reduction target as a Sydney case study.

3.1.2 Case Study of Sydney's Waste Management System

Global cities wrestle with a sustainability paradox in straddling economic competition and environmental pressures (Boschken, 2013; Hu, 2015). The City of Sydney local government area is no exception to the sustainability paradox (Hu, 2015); generating more than 25% of the state's (New South Wales) gross domestic product (GDP) while implementing a Sustainable Sydney 2030 strategy (City of Sydney, 2017c). This section will introduce Sydney as a city whose waste management has received little attention in the literature. It will then discuss foundational information on the city's waste reduction target. Finally, it will outline the significant social-economic and political context of the city case study to inform the findings of the thesis research.

Zaman and Lehmann (2011a) claim that holistic systems approaches are required to provide a rich understanding of a dynamic city waste system and therefore achieve a high impact in city waste reduction targets. Despite this, there are limited examples of city waste reduction targets that have adopted a systems approach (Zaman, 2015). In conducting a review of zero waste related papers between 1995 and 2014, Zaman (2015) only identified 96 relevant journal publications for review. While 43% of the 96 papers included zero waste concepts in holistic waste management systems approaches (Zaman, 2015), this is a relatively small number of studies in a 19-year period. Additionally, the review summary table in the paper's appendix shows only eight of the papers that included zero waste concepts in holistic waste management systems approaches used in an Australian case study (and the lead author for 6 of those 8 papers was Zaman):

1. Connet, P. 2007. Zero Waste: a key move towards a sustainable society. *New York. USA.*
2. Lehmann, S. 2011. Optimizing urban material flows and waste streams in urban development through principles of zero waste and sustainable consumption. *Sustainability,* 3**,** 155-183.
3. Zaman, A. U. & Lehmann, S. 2011. Challenges and opportunities in transforming a city into a "zero waste city". *Challenges,* 2**,** 73-93.
4. Zaman, A. U. & Lehmann, S. 2011. Urban growth and waste management optimization towards 'zero waste city'. *City, Culture and Society,* 2**,** 177-187.
5. Zaman, A. U. & Lehmann, S. 2013. Development of demand forecasting tool for natural resources recouping from municipal solid waste. *Waste management & research,* 31**,** 17-25.
6. Zaman, A. U. & Lehmann, S. 2013. The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'. *Journal of Cleaner Production,* 50**,** 123-132.
7. Zaman, A. U. 2014. Identification of key assessment indicators of the zero waste management systems. *Ecological indicators,* 36**,** 682-693.
8. Zaman, A. U. 2014. Measuring waste management performance using the 'Zero Waste Index': the case of Adelaide, Australia. *Journal of Cleaner Production,* 66**,** 407-419.

The gap in Australian literature regarding Australian examples of zero waste concepts in holistic waste management systems approaches is therefore large, with only 8 papers published over 19 years by 3 authors: Connett, Lehmann and Zaman. None of these 8 papers included a holistic study of the waste management system in Sydney, the most populated city in Australia.[16]

[16] 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.

This chapter addresses this gap by taking a holistic approach to assessing the city case study's waste management system in relation to its waste reduction target, the City of Sydney and its 2030 zero waste target. This extends the work of Zaman and Lehmann (2013b) and Zaman (2014b), who holistically assess city zero waste targets. Holistic assessment is conducted in this chapter by reviewing parts in the system (such as communication and public reporting) and their interconnected relationships in addition to traditional waste diversion metrics used by the City of Sydney. In doing so, it will be the first holistic study of an active city waste management system in Sydney. Section 1.2 will first discuss the contextual framing for zero waste in practice, then the socio-economic and political context surrounding the City of Sydney that inform the interpretation of findings in this chapter.

3.1.2.1 Zero Waste as a Waste Reduction Target

Discussing the framing of zero waste in practice provides insight into how this phrase is interpreted in the field of waste management and highlights the demand for a Sydney-based case study that features a holistic approach to assessing a waste management system attempting a zero waste target.

Despite its seeming transparency, zero waste has an elusive historical record of confusion and poor implementation, representing more than 'zero' waste. The ideals and application of zero waste stand in contrast to each other. The speed of initial conceptual communication in the words 'zero waste' carries a time handicap for those wishing to apply the vague and mostly unstructured concept in practice. Despite the Zero Waste International Alliance adopting the first internationally-accepted and peer-reviewed definition of zero waste in 2004 (ZWIA, 2022), the definition and application of zero waste still varies greatly between users; see Section 4.2.1. For the purposes of explaining the basic principles of zero waste, this thesis will lean on the definition offered by Zaman and Lehmann (2013b, p. 124); "zero waste means no unnecessary and unwanted waste from a product at any stage of its life cycle".

Despite the complications associated with zero waste in practice, it has been popular in waste management both historically (predominantly in the 1970s and 1980s) and more recently (in the 2010s and early 2020s); see Figure 3.3. In academic publishing, the number of zero waste studies has grown since 2003, with a review of 96 peer-reviewed journal publications on zero waste between 1995 to July 2014, identifying 81 case studies over 28 countries (Zaman, 2015). This growth in academic attention on domestic zero waste is evident, with Australia and USA most highly represented, having 12 case studies each (Zaman, 2015). Despite the Australian-based researcher Zaman (2015) outlining that achieving zero waste goals is dependent upon establishing national zero waste strategies, to date, there is no domestic national zero waste agenda in Australia.

Year	Country	Milestones/events
1970s	USA	The term 'Zero Waste' was coined by Paul Palmer.
1986	USA	The National Coalition against Mass Burn Incineration was formed.
1988	USA	Seattle introduced the Pay-As-You-Throw (PAYT) system.
1989	USA	The California Integrated Waste Management Act was passed to achieve 25% waste diversion from landfill by 1995 and 50% by 2000.
1990	Sweden	Thomas Lindhqvist introduced 'Extended Producer Responsibility.'
1995	Australia	Canberra passed the 'No Waste by 2010' bill.
1997	New Zealand, USA	• The Zero Waste New Zealand Trust was established. • The California Resource Recovery Association (CRRA) organized conference on zero waste.
1998	USA	Zero waste was included as guiding principles in North Carolina, Seattle, Washington, and Washington, DC.
1999	USA	The CRAA organised zero waste conferences in San Francisco.
2000	USA	The Global Alliance for Incinerator Alternatives was formed.
2001	USA	GrassRoots Recycling Network published 'A Citizen's Agenda for Zero Waste.'
2002	New Zealand, USA	• The book *Cradle-to-Cradle* was published. • Zero Waste International Alliance was established. • The First ZW Summit was held in New Zealand.
2004	Australia, USA	• ZWIA gives a working definition of zero waste. • GRRN adopts ZW business principles. • Zero Waste SA was established in South Australia.
2008	USA	The Sierra Club adopted a zero waste producer responsibility policy.
2012	USA	• The documentary film *Trashed* premiered at the Cannes Film Festival. • The Zero Waste Business Council was established in the USA.

(Adapted from Connett (2013b).)

Figure 3.3. 'Key milestones and events on the zero waste development', sourced from Zaman (2015, p. 2)

'Circular economy' is another popular phrase and concept that has emerged in recent years as a competitor, or counterpart, to zero waste in government, industry and academia. Despite zero waste's longer lineage in the waste management field, that phrase 'circular economy' is rapidly becoming more commonly used; supported through the promotion of leading organisations such as the Ellen MacArthur Foundation (2022b, 2022a). The relationship between these two terms is discussed further in Chapters Three and Four of this thesis.

Zero waste has previously been implemented as a city waste reduction target with notable examples such as San Francisco, Stockholm and Adelaide achieving high levels of measurable success (Un-Habitat, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2013b). Despite this, there has not yet been a fully successful attempt at zero waste as a city waste reduction target. This is in part a consequence of the metrics designed to measure such attempts. For example, Zaman (2015) believes that achieving 100% diversion from landfill for a zero waste target is not currently possible.

3.1.2.2 City of Sydney's Waste Management System

Discussing the socio-economic and political contexts for waste management in Sydney, and in Australia more broadly, this thesis follows a systems approach by acknowledging interconnected parts that inform the interpretation of findings in this chapter.

Sydney is the most populated state capital city in Australia (Australian Bureau of Statistics, 2019), recorded at 4.9 million in 2015 (City of Sydney, 2017a), 5 million in 2019 (Australian Bureau of Statistics, 2019) and projected to reach 6.4 million by 2036 (City of Sydney, 2017a; Australian Bureau of Statistics, 2019). The name 'Sydney' is used to describe two different boundaries in the region: 1) 'Greater Sydney' (sometimes referred to as 'Metropolitan Sydney' in supporting texts) describes the 12,368 km^2 geographic region containing many local government areas (City of Sydney, 2017a), and 2) 'City of Sydney' describes the 26km^2 local government area

(City of Sydney, 2019a, 2017b) south of the Sydney Harbour Bridge and includes the central business district (CBD).[17] It is this City of Sydney local government area, and its existing 2030 zero waste target, that is included as a city case study.

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. With a dense population of 240, 229 (City of Sydney, 2019a), at approximately 5,000 people per km^2 (City of Sydney, 2018), the area provides a concentrated sample size, being 4.6% of the Greater Sydney population (City of Sydney, 2019a). The median age is relatively young (32 years) and 50% of residents are aged between 18-34 (City of Sydney, 2017a). A culturally diverse city – 50% of the residents are born overseas (City of Sydney, 2017a). Many residents are tertiary educated; 48% of residents have a bachelor degree or higher (City of Sydney, 2017a). Additional daily occupation is estimated at 1.2 million people (visitors, students, and commuting workers) who are not included in population data.[18]

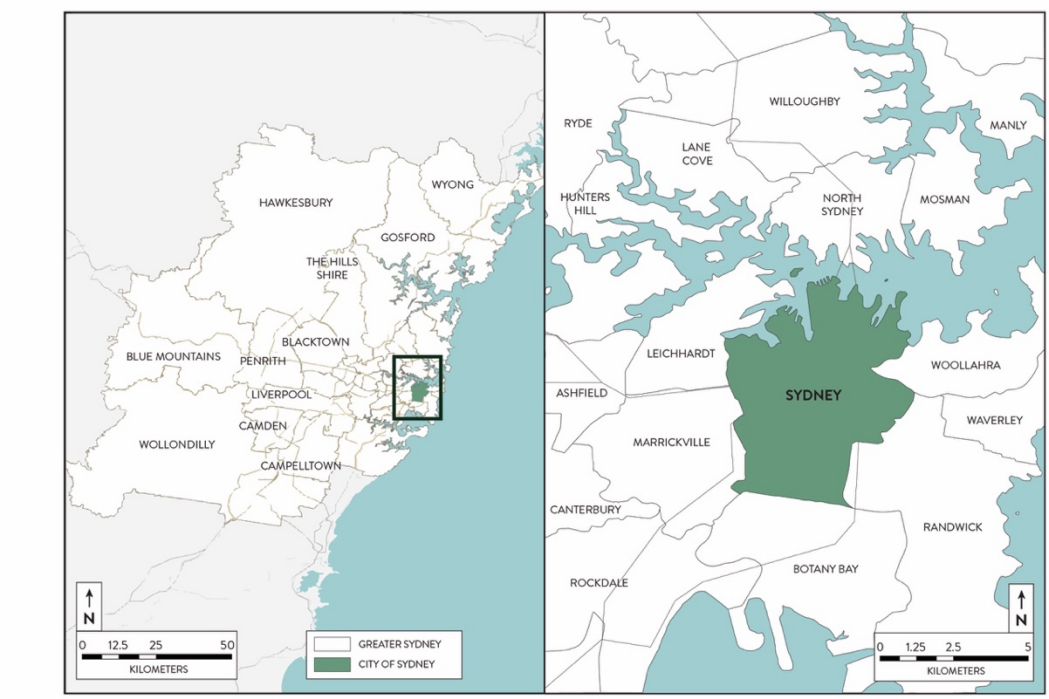

Figure 3.4. Scale of the City of Sydney within the Greater Sydney area, adapted from Hu (2015, p. 4552)

[17] The City of Sydney houses 20,000 businesses and 437,000 jobs (City of Sydney, 2017a; 2017b).

[18] It is unclear if people experiencing homelessness are included in the available population data.

The larger Australian waste management context informs the City of Sydney case study under review in this research. Trends in the national waste management system therefore inherently frame and inform the lens within which the city case study can be better understood. Australia is one of the highest consuming countries, producing 67 million tonnes of waste per annum (Commonwealth of Australia, 2018). Total national waste production in Australia has grown by 134% over eighteen years; as publicly reported in the national waste reports (32.4 Mt in 2002-03, 75.9 Mt in 2020-21); see Figure 3.5 and Table 3.1. Comprehensive nation waste reports on Australian waste management and recycling began being publicly reported twelve years ago in 2010 (DEWHA, 2010). These were developed based on information reported by government agencies to the Australian Government's Department of Climate Change, Energy, the Environment and Water (DCCEEW). Previously, they were published every three years (DEWHA, 2010) until 2016 and are now generated every two years (i.e. 2010, 2013, 2016, 2018, 2020, 2022).[19]

The growth of waste production over the eighteen-year period (134%) could be influenced by several key factors. Firstly, population growth can increase consumption and therefore waste production across all sectors: municipal solid waste (MSW), commercial and industrial sector (C&I), as well as construction and demolition sector (C&D). Secondly, increased or improved reporting to and by government agencies over time may have increased the amount of waste reflected in reporting compared to previous years. Thirdly, changes in the federal government structure over time may shape approaches and expectations for public reporting of waste (e.g., responsibility for these reports was passed through three different departments during the sixteen-year period). Finally, while there is a national standard for waste and resource recovery data and reporting, compliance is most likely limited because: 1) the standard was provided for "opportunistic and voluntary adoption when convenient" (Blue Environment, 2021, p.1), and 2)

[19] The last four reports in 2016, 2018, 2020, and 2022 have been prepared by a third-party consultant organisation called Blue Environment.

it was only introduced 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 rigor in waste management (as well as documentation and reporting of waste production).

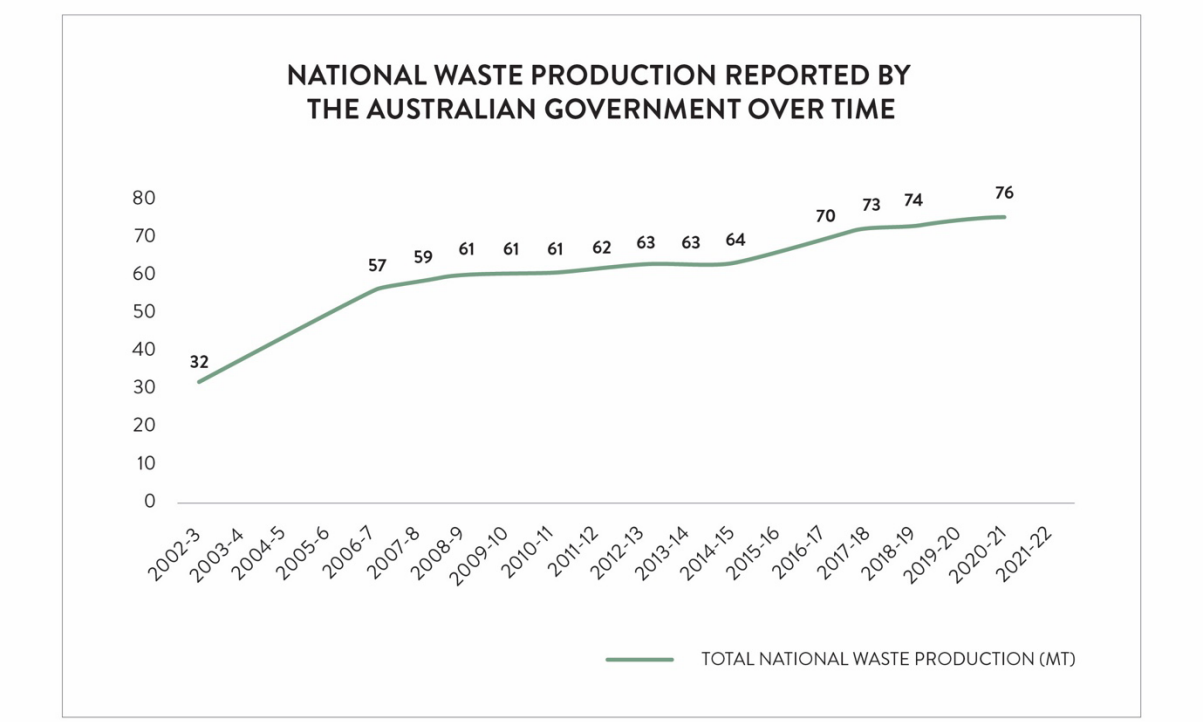

Figure 3.5. National waste production reported by the Australian government over time*

Mt = Million Tonnes

* Data used to generate this graph reflect those curated in Table 3.2, rounded up to the nearest whole number. Where there were two figures reported for the same year (2006-07, 2010-11, and 2016-17), the most recent reporting for that year was used.

Table 3.1. Annual total national waste production reported by the Australian government

Mt = Million Tonnes

Year	Total National Waste Production	Source	Notes
2002-03	**32.4 Mt**	DEWHA. (2010). *National Waste Report 2010*. EPHC.	-
2003-04	N/A	-	Waste data from this year was not reported in the National Waste Reports.
2004-05	N/A	-	Waste data from this year was not reported in the National Waste Reports.
2005-06	N/A	-	Waste data from this year was not reported in the National Waste Reports.
2006-07	43.777 Mt	DEWHA. (2010). *National Waste Report 2010*. EPHC.	The first comprehensive nation waste report that detailed Australian waste management and recycling.
2006-07	**57 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	Reports a larger figure for total national waste production in 2006-07 than that documented in the previous report (DEWHA, 2010).
2007-08	**59 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2008-09	**61Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2009-10	**61Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2010-11	62 Mt	Department of the Environment. 2013. National Waste Report 2013. Department of the Environment.	This report was hosted on the Department of Environment website as a series of separate documents that could be accessed quickly by readers and updated with new information.
2010-11	**61Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	Reports a smaller figure for total national waste production in 2010-11 than that documented in the previous report (Department of the Environment, 2013).
2011-12	**62 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-

2012-13	**63 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2013-14	**63 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2014-15	**64 Mt**	Blue Environment. 2016. Australian National Waste Report 2016. DEE.	-
2015-16	N/A	-	Waste data from this year was not reported in the National Waste Reports.
2016-17	67 Mt	Blue Environment. 2018. National Waste Report 2018. DEE.	Major fires caused by waste stockpiling (particularly in construction and demolition) were flagged as a point of concern; noting that these stockpiles are typically underreported.
2016-17	69 Mt	Blue Environment. 2020. National Waste Report 2020. Blue Environment Pty Ltd.	Reports a larger figure for total national waste production in 2016-17 than that documented in the previous report (Blue Environment, 2018).
2016-17	**69.7 Mt**	Blue Environment. 2022. National Waste Report 2022. DCCEEW.	Reports a larger figure for total national waste production in 2016-17 than that documented in the previous report (Blue Environment, 2020).
2017-18	**73 Mt**	Blue Environment. 2020. National Waste Report 2020. Blue Environment Pty Ltd.	-
2018-19	**74.1 Mt**	Blue Environment. 2020. National Waste Report 2020. Blue Environment Pty Ltd.	-
2019-20	N/A	-	A report for this year is yet to be published.
2020-21	**75.9MT**	Blue Environment. 2022. National Waste Report 2022. DCCEEW.	**-**
2021-22	N/A	-	A report for this year is yet to be published.

Legislation, policy and agreements govern or impact the City of Sydney waste management system; see Table 3.2. These extend across four primary levels of jurisdiction: 1) international, 2) national, 3) state or territory, and 4) local government area. According to Jones (2020), responsibility for waste in Australia is emphasised at state levels of government (who are 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 make change or contribute directly to shaping waste policy (Jones, 2020). Older legislation, policy, or agreements in Table 3.2 address local government, while more recent works are internationally relevant. This suggests different rates of change in each level of jurisdiction that might impact change in improving waste management systems towards waste reduction targets. For example, while the City of Sydney has associated itself with international agreements such as the UN Sustainable Development Goals (SDGs), a plan of how the local government will make specific changes towards this goal is yet to be publicly reported.

Waste has not been maintained as a political priority for Australia at a national level where constitutional and institutional factors to change in waste management systems were identified by Jones (2020). A strong contribution of the findings of Jones (2020) was the disconnect observed between different levels of government that have empowered private industry to become influential stakeholders in decision making; as driven by economic factors.

Table 3.2. Levels of jurisdiction in legislation, policy or agreements that govern or impact the City of Sydney

Jurisdiction Levels	**Year**	**Legislation, Policy or Agreement**	**Appearance in Sources**
International *(Global)*	2015	UN Sustainable Development Goals by 2030 (one of 193 participating countries)	(City of Sydney, 2017a)
	2015	Paris Climate Agreement at the 21st Conference of the Parties (COP21)	(City of Sydney, 2017a)

National *(Australia)*	1992	National Strategy for Ecologically Sustainable Development	(Commonwealth of Australia, 2013)
	1994	The National Environment Protection Measures under the National Environment Protection Council Act	(Commonwealth of Australia, 2013)
	2009	The National Waste Policy	(Commonwealth of Australia, 2013)
	2011	Product Stewardship Act	(Commonwealth of Australia, 2013)
State or Territory *(New South Wales)*	1997	The Protection of the Environment Operations Act	(Commonwealth of Australia, 2013)
	2001	The Waste Avoidance and Resources Recovery Act	(Commonwealth of Australia, 2013)
	2012	Integrated Planning and Reporting framework for NSW Local Government	(City of Sydney, 2017a)
	2017	The Waste Avoidance and Resources Recovery Strategy	(Commonwealth of Australia, 2013)
Local Government Area *(City of Sydney)*	1988	City of Sydney Act	(City of Sydney, 2019b; City of Sydney, 2017a)
	1993	Local Government Act	(City of Sydney, 2019b; City of Sydney, 2017a)

While waste management and public reporting in Australia have received more attention in the media over recent years, waste production continues to rise and the urgency of intervention increases. A universal approach for the national management, measurement or reduction of waste is yet to be implemented in Australia's waste management system. This absence of overarching planning has resulted in an unstable system that can easily be impacted by changes in its system context. The delivery of core waste services are then vulnerable in the face of unanticipated change; for example, the mass panic and dumping of waste triggered by the China Sword policy in 2018 (Downes, 2018, Staub, 2018). The policy mandated a strict contamination threshold for China's waste imports that blocked Australia from continuing to export a large proportion of its waste offshore without a viable domestic alternative (Downes, 2018; Staub,

2018).[20] Chapter Four of this thesis will discuss the impact of pivotal events such as the 2018 China Sword policy in greater depth.

Additionally, while this thesis was being written, Australia experienced a series of unanticipated and radical shocks to the system: 1) the Covid-19 pandemic; 2) seasonally recurring natural disasters (bush fires and floods); 3) political and financial knock-on effects of international conflict (between Russia and Ukraine) that is radically increasing the cost of living; and 4) the housing crisis. Each of these had visible impacts on Australia's waste management system (e.g., Covid-19 increased disposable health-related materials such as masks and rapid antigen tests being used by consumers). These unanticipated and radical shocks change the context of any waste reduction attempts (e.g., waste reduction programs in flood-affected regions are very unlikely to observe high performance due to the destruction of homes and personal property).

3.2 Results: Desktop Review of a City Waste Management System

A desktop review was conducted to provide descriptive evidence of the city waste management system as it transitions towards zero waste by 2030; see Section 2.4.1. Three key challenges to target implementation and impact measurement were observed: 1) poor communication of the target by the City of Sydney; 2) conflicting and incomplete publicly reported waste data by the City of Sydney; and 3) an absence of publicly reported waste data by other key stakeholders.

[20] The local government council of Ipswich in Queensland (QLD) was one such area featured in the media for temporarily delivering their collected 'recycling' waste directly into landfill for four weeks when high contamination rates of collections did not meet the standards required by China's Blue Sky Policy (Bavas, 2018).

3.2.1 Challenges to Target Implementation and Impact Measurement

In exploring and describing an active city waste management system attempting a waste reduction target, three key challenges to target implementation and impact measurement were observed. Firstly, poor communication of the target by the City of Sydney, including a complicated and poorly communicated zero waste target. Secondly, conflicting and incomplete publicly reported waste data by the City of Sydney, including waste quantities, budgeting and transport. Thirdly, an absence of publicly reported waste data by other key stakeholders (such as contractors, partner organisations or non-for-profits) that may have been able to address city public reporting gaps previously observed.

3.2.1.1 City of Sydney Engagement: Poor Target Communication

While commendably ambitious, the 2030 zero waste target set by the City of Sydney is complicated in structure and detail, impacting communication with the general public and key stakeholders.[21] Variations of the tagline 'zero waste by 2030' can be viewed sporadically in the media and within some City of Sydney reports; however, what this target means and who it applies to is much more difficult to identify. For example, in conducting a search on the City of Sydney website for the phrase 'zero waste' during October 2021, the only item found was a brief blog titled 'How to have a zero-waste picnic' that was 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 via

[21] One area of achievement was in their advertising method, where The City of Sydney commissioned an advertising campaign by Paper Moose to minimise street dumping as a part of their Zero Waste initiative. This featured outdoor vinyl stickers of household waste commonly dumped (such white goods and furniture) around the city and was awarded a Good Design Award in 2017 (Good Design Australia, 2017; Paper Moose, 2017). This award, while an achievement, does not reflect the level of community engagement with the target, nor the level of impact the intervention created.

searching for the target's title. The poor communication on a basic introductory level to the public on the city's own website is an indication of the challenges presented to someone to engage with, let alone make change towards, this waste reduction target.

A simple explanation of this target is 90% diversion of solid waste from landfill, as set eleven years ago in 2010 under the Sustainable Sydney 2030 strategy (City of Sydney, 2017c, 2017a). What this simple explanation does not disclose is which waste streams this target addresses. Like any local government area in NSW, the City of Sydney is only responsible for, and therefore has authority over, solid waste that it directly manages. This is referred to as 'municipal waste'.[22] Municipal waste in this case study area represents about 6.7 million tonnes per annum (City of Sydney, 2017c), which is only 10% of the total waste being generated in the local government area (67 million tonnes per annum (Commonwealth of Australia, 2018)). It is this 10% of waste that the formal 2030 zero waste target from the City of Sydney covers, and could be considered marginal compared to total waste production in the local government area; an important detail that is not make explicit, nor easy to find in the public domain.

A more detailed explanation of the target would be to identify that there is a second informal target that the City of Sydney has set over waste streams that it is not directly responsible for.[23] This second target covers the other 90% of solid waste (over 60 million tonnes

[22] In the City of Sydney, municipal waste includes solid waste from: 1) city parks, streets, and public places, 2) city-managed properties, 3) construction and demolition generated and managed by city operations (City of Sydney, 2017c).

[23] To further complicate the distinction of responsibility is regard to this waste target, there are competing messages from different governing bodies; the Australian Government Department of the Environment and Energy identifies local and state government as primarily responsible for waste management Act (Commonwealth of Australia, 2013), while the City of Sydney calls on other government agencies and regulators to: 1) support waste prevention in object use design and industry responsibility; 2) allocate land in Greater Sydney for waste treatment and transfer; 3) provide independent education for the public regarding environmental impacts of waste treatment (including waste-to-energy); (4) improve transparency of waste data between stakeholders in the system (including residents, industry and waste operators); and 5) provide more national product stewardship schemes under the Product Stewardship Act (City of Sydney, 2017c; Commonwealth of Australia, 2013).

per annum) that is produced in the area (Commonwealth of Australia, 2018) from: 1) residential, 2) commercial and industrial, and 3) construction and demolition (City of Sydney, 2017c) sources. In reviewing publicly accessible documentation form the City of Sydney, no evidence was observed that this distinction between targets was communicated directly to impacted stakeholders from these waste streams, outside of the downloadable reports on their website as pdf attachments (that requires a stakeholder to actively seek out the information). There was also no observed evidence of co-design of, or consultation about the target and strategy with impacted stakeholders, despite these waste streams being the dominant producers of waste in the City of Sydney local government area. Despite representing the majority of the waste produced in the local government area, this second informal target is relatively quiet in both the formal documentation and any supporting communication by the city to the public or key stakeholders. This presents a challenge for stakeholders with power to influence to make any change towards the waste reduction target, when there is a communication barrier between two communities of practice: local government and industry.

The communication of this waste reduction target may therefore have a detrimental impact on the city's own efforts for system change, when key information about the target strategy is not clearly conveyed to the general public and key stakeholders. This includes: 1) the marginal quantity of city waste production that the formal 2030 zero waste target addresses (i.e., level of possible achievable impact) and how that information is communicated; as well as 2) the communication of the secondary informal target (especially to the key stakeholders from those waste streams who are in a position of power to make change). Specific actions that the city will take to achieve their formal 2030 zero waste target were also difficult to find in publicly accessible documents; planned activities towards the target were often vague without a method of measurement or a monitoring strategy. The details of this target (or rather two targets) are not only unnecessarily complicated and poorly communicated in publicly available city documents, but could also be considered as misleading; where 'zero waste by 2030' could easily be

misunderstood as an elimination of all solid waste produced in the area. If the City of Sydney were to achieve their formal 2030 zero waste target, it would only reduce the total waste produced in the local government area in 2017 and 2018 by 9%.[24] While all waste reduction achievement should be celebrated, this percentage is a small fraction of the total waste and its reduction would not align with the message conveyed by the phrase zero waste.

3.2.1.2 City of Sydney Reporting: Conflicting and Incomplete Data

In the search for measured weight and associated costs of solid waste management in the city, three linked reports published by the City of Sydney in 2017 were primarily 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); see Tables 3.3, 2.4, 3.5, 3.6, and 3.7. Observed across these documents were: 1) conflicting data, 2) inconsistencies in annual reporting, and 3) an absence of key information. These hinder the exploration and description of the city transitioning towards a waste reduction target that is required to understand the waste management system (that informs change). It also prevents the calculation of waste reduction process and projected trends from publicly reported quantitative data.

Conflicting data was observed where different language was used to report the same (or similar) waste measurement across linked documents published by the city in the same year.[25] For instance, waste data from 2015-16 reports 275 tonnes from City of Sydney 'managed properties' (City of Sydney, 2017b) and 400 tonnes from City of Sydney 'buildings' (City of

[24] 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).

[25] Waste data was not the only source of conflicting data reported across these reports, where 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 both 300,000 by 2030 (City of Sydney, 2017a) and 280,000 by 2036 (City of Sydney, 2017b).

Sydney, 2017c), see Table 3.5. Here the descriptors used are similar, yet report vastly different weight measurements, making it difficult to reconcile an accurate reflection of waste from any one source. Another example of this can be observed where waste data from 2015-16 reports 723 tonnes from City of Sydney 'parks' (City of Sydney, 2017b) and 11,000 tonnes from City of Sydney 'parks, streets and public spaces' (City of Sydney, 2017c), see Table 3.5. Here, the conflict of reported waste quantities from the same year and same (or similar) waste sources is reported differently across linked documents published by the city in the same year. This makes it difficult to determine which of the reported data is a correct (or most accurate) reflection of waste production when seeking to understand the city waste management system, and therefore inform change towards its waste reduction target.

Inconsistencies in annual reporting were observed where measurements from specific waste streams and sources were reported in some years and absent in others. For instance, the city reported 700,000 tonnes from the 'commercial & industrial' waste stream in 2017, yet no observation of any waste data from this stream in 2015-16 (or any other year), see Table 3.6. A similar inconsistency was observed where the city projected 1,500,000 tonnes from the 'construction & demolition' waste stream in 2030, yet no observation of any waste data from this stream in 2015-16, 2017 (or any other year), see Table 3.7.[26] Inconsistencies in annual reporting were also observed, where waste components were shown as percentages of an unknown total waste quantity. For instance, the city reported percentage ratios of eight different waste sources within the 'residential general waste bin contents' waste stream for 2017, and eight different waste sources within the 'commercial & industrial' waste stream for 2015-16 (City of Sydney, 2017c) without a source number or overall total to show the amount of waste, see Table 3.5 and

[26] 'Construction and Demolition' waste listed in Tables 3.5 and 3.6 reflect municipal projects, not the industries of construction and demolition. While the figure listed in Table 3.6 showing 700,000 tonnes of 'construction and demolition' waste from a mixed source was reported, it listed the City of Sydney as responsible for 400,000 tonnes and did not explain the remaining 300,000 tonnes.

3.6. Both the inconsistency of reporting from the same waste streams over time and the lack of clarity around total waste quantities that inform compositional percentages hinder the capacity for understanding the city waste management system as it transitions towards zero waste, and therefore the capacity to change towards that target.

Table 3.3. Waste production reported for the year 2012 in the City of Sydney area

Note: here 't' refers to metric tonnes (where 1t = 1,000kg)

Number	Unit	Quantifier	Year	Location/Sources	Responsible Collector/Manager	Data Sources
267,000	t	Annually	2012	**Commercial & Industrial**	**Businesses**	(City of Sydney, 2017b)
80	%	Total city waste				

Table 3.4. Waste production reported for the year 2014 in the City of Sydney area

Note: here 't' refers to metric tonnes (where 1t = 1,000kg)

Number	Unit	Quantifier	Year	Location/Sources	Responsible Collector/Manager	Data Sources
20	t	One Day	2014-15	**New Year's Eve street waste**	**City of Sydney**	(City of Sydney, 2014-15)

Table 3.5. Waste production reported for the year 2015 in the City of Sydney area

Note: here 't' refers to metric tonnes (where 1t = 1,000kg)

Number	Unit	Quantifier	Year	Location/Sources	Responsible Collector/Manager	Data Sources
121	t	Disposal in year	2015-16	**White goods removed from streets**	**City of Sydney**	(City of Sydney, 2014-15)
3,208	No.	Disposal in year	2015-16	**Mattresses removed from streets**		(City of Sydney, 2014-15)
22,937	No.	Disposal in year	2015-16	**Dumps removed from streets**		(City of Sydney, 2014-15)

8,740	t	Disposal in year	2015-16	**Street cleansing Waste Collected**		(City of Sydney, 2014-15)
28	t	Disposal in year	2015-16	**City of Sydney construction & demolition**		(City of Sydney, 2017b)
275	t	Disposal in year	2015-16	**City of Sydney managed properties**		(City of Sydney, 2017b)
723	t	Disposal in year	2015-16	**City of Sydney parks**		(City of Sydney, 2017b)
1,456	t	Disposal in year	2015-16	**City of Sydney (inc. storm water waste)**		(City of Sydney, 2017b)
3,000	t	Disposal in year	2015-16	**City of Sydney Public (inc. place waste)**		(City of Sydney, 2017b)
3,996	t	Disposal in year	2015-16	**City of Sydney streets waste (inc. illegal dumping)**		(City of Sydney, 2017b)
75,000	t	Annually	2015	**Residential** ***(100,000+ Households)***		(City of Sydney, 2017b)
400	t	Annually	2015-16	**Municipal buildings**		(City of Sydney, 2017c)
11,000	t	Annually	2015-16	**Municipal parks, streets & public spaces**		(City of Sydney, 2017c)
53 3 3 3 1 3 13 21	% % % % % % % %	Accommodation & entertainment Other Industrial Healthcare Education Community Retail Commercial office	2015-16	**Commercial & Industrial**	**Businesses**	(City of Sydney, 2017c)

Table 3.6. Waste production reported for the year 2017 in the City of Sydney area

Note: here 't' refers to metric tonnes (where 1t = 1,000kg)

Number	Unit	Quantifier	Year	Location/Sources	Responsible Collector/Manager	Data Sources
4,000	t	Annually	2017	**Illegal dumping**	**City of Sydney**	(City of Sydney, 2017c)
35	%	Total waste managed by City of Sydney cleansing team				(City of Sydney, 2017c)
65,000	t	Annually	2017	**Residential *(115,000+ Households)***		(City of Sydney, 2017c)
1	kg	Daily per Resident				(City of Sydney, 2017c)
313	kg	Annually per Resident				(City of Sydney, 2017c)
40 8 6 1 2 6 35 3	% % % % % % % %	Other Paper & cardboard Glass bottles Steel packaging Plastic textiles & carpet Food Garden vegetation	2017	**Residential general Waste bin contents**		(City of Sydney, 2017c)
11,000	t	Annually	2017	**Municipal *(City of Sydney managed assets, parks & public spaces)***		(City of Sydney, 2017c)
4	%	Total city waste to landfill	2017	**Total City of Sydney waste**		(City of Sydney, 2017c)
<1	%	Total city carbon emissions				(City of Sydney, 2017c)
4,000	t	Annually	2017	**Municipal Construction & Demolition**		(City of Sydney, 2017c)

>1,200,000	t	Annually	2017	**Total Construction & Demolition**	**Mixed** ***(City of Sydney for 400,000 tonnes)***	(City of Sydney, 2017c)
4	kg	Daily per employee or visitor				(City of Sydney, 2017c)
53	%	Total city waste to landfill				(City of Sydney, 2017c)
1	%	Total city carbon emissions				(City of Sydney, 2017c)
700,000	t	Annually	2017	**Commercial & Industrial**	**Businesses**	(City of Sydney, 2017c)
>90	%	Total city waste				
2	kg	Daily per employee or visitor				(City of Sydney, 2017c)
43	%	Total city waste to landfill				(City of Sydney, 2017c)
7	%	Total city carbon emissions				(City of Sydney, 2017c)
140,000	t	Annually	2017	**E-Waste**	**Australians**	(City of Sydney, 2017b)

Table 3.7. Waste production projections for the year 2030 in the City of Sydney area

Note: here 't' refers to metric tonnes (where 1t = 1,000kg)

Number	**Unit**	**Quantifier**	**Year**	**Location/Sources**	**Responsible Collector/Manager**	**Data Sources**
<80,000	t	Annually	2030	**Residential**	**City of Sydney**	(City of Sydney, 2017b)
87,000	t	Annually	2030			(City of Sydney, 2017c)
15,000	t	Annually	2030	**Municipal**		(City of Sydney, 2017c)
>100,000	t	Annually	2030	**Total City of Sydney waste**		(City of Sydney, 2017c)
307,000	t	Annually	2030	**Commercial & Industrial**		(City of Sydney, 2017b)

>800,000	t	Annually	2030			(City of Sydney, 2017c)
1,500,000	t	Annually	2030	**Total Construction & Demolition**	**N/A**	(City of Sydney, 2017c)

Absence of key information was observed where the location of waste moving through known checkpoints in the system and budgeting for the target was not observed in the city's public accessible documents. For instance, while it is known that localised landfills in Greater Sydney are rapidly decreasing in capacity (City of Sydney, 2017b) and the use of five landfill cells outside the city increasing (Sohkhlet, 2019), there was no information in City of Sydney public documents about where the city's waste is being sent; see Figure 3.7.[27] A similar absence of key information was observed where 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) were not observed in the city's public documents.

Further absences of key information were also observed where financial records and projections in the city's public documents did not include explanations of waste management spending. For instance, the city has reported projected waste disposal charges to cost A$28.8 million in 2028-29 (A$6.7 million more than the projected A$22.1 million in 2019-20) (City of Sydney, 2019b, 2020) and included no discussion outlining how these funds would be spent or why waste disposal charges would increase. This is despite a 2030 zero waste target defined as 90% diversion from landfill (i.e., less waste by the year 2028). Additionally, when the 2019-20 budget total was calculated with 1% inflation to 2028-29, it was observed as being A$24.2 million – less than the A$28.8 million budgeted for by the city; see Figure 3.6. Another similar absence

[27] The five primary landfill sites used by Greater Sydney are Jack's Gully, Genesis Facility at Eastern Creek, Lucas Heights, Belrose, and Woodlawn landfill at Tarago; see Figure 3.7 (Sohkhlet, 2019). Woodlawn landfill in particular, operated by Veolia, is the Australian landfill which receiving the largest amount of waste (400,000+ tonnes per year) and is accessed by Greater Sydney via rail (Sohkhlet, 2019).

of key information was observed where City of Sydney services charges (such as rental trucks, compactors or bins) were publicly reported, however the 'tipping fees' associated with these services were vaguely listed as "fee +GST" (City of Sydney, 2019b, p.117).[28]

Not only is the public reporting from the city regarding its waste management incomplete and competing across documents, but the scattered nature of information across multiple documents hinders understanding of the weight or cost of city waste management system as it transitions towards zero waste, and therefore the capacity to change towards that target. Additionally, the lack of discussion around future waste budgeting that directly impacts the 2030 zero waste target brings into question the depth of consideration given to the strategy, and its validity.

Figure 3.6. Primary landfills used by greater Sydney and geographic proximity, sourced from Sohkhlet (2019, p. 5)

Note: here the white circle represents a 50km radius from Greater Sydney

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

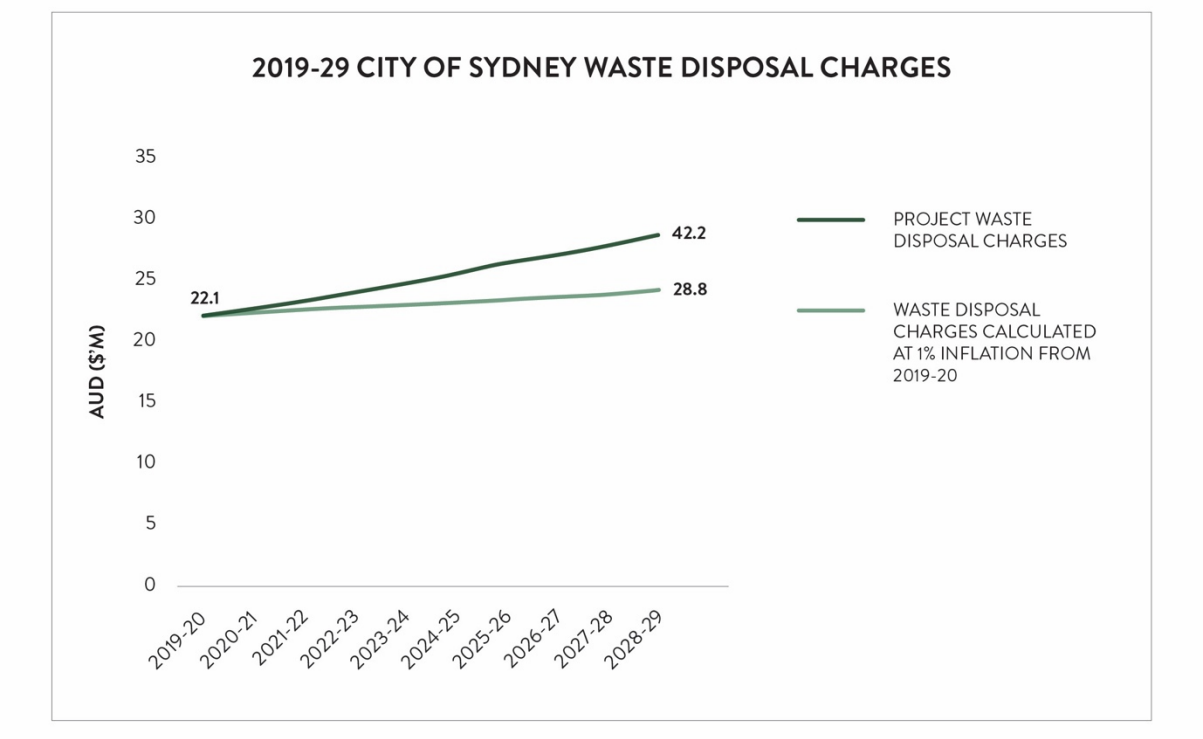

Figure 3.7. Projected inflation of waste disposal charges for the City of Sydney 2019-2029

Note: Waste Disposal Charges in Figure 3.6. are calculated at 1% from 2019-20, calculated using the 2019-20 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

3.2.1.3 Stakeholder Reporting: Absent Waste Data

Secondary data from key stakeholders to support information from the City of Sydney regarding the measured weight and associated costs of solid waste management was not observed in publicly accessible documentation. Nineteen stakeholders were named as involved in city waste management within public documentation; seventeen were named by the City of Sydney (2017a, 2017b, 2017c, 2018, 2014-15) and two named by related sources (James, 2019; Sohkhlet, 2019). Stakeholders listed by the City of Sydney were:

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.

Stakeholders listed by related sources were:

1. The Environmental Committee of the City of Sydney Council, and
2. The Freecycle Network.

Despite this, there was no observation of any publicly available data on city waste weight or associated cost publicly available and reported by these key stakeholders; see Table 3.4. This included any further supporting data about contributions from different waste streams, locations or processing of waste, or the role of specific contractors involved in the target. This absence is

notable not only from the challenge it presents to learning about the waste management system, but it also does not address any of the information gaps previously identified in the city public reporting.

Table 3.8. Key stakeholders in the City of Sydney local government area

Number	Unit	Quantifier	Organisation/Individual	Role/Relationship	Appearance in Sources
1	Person	2017	Clover Moore	Lord Mayor of City of Sydney	(City of Sydney, 2017c)
N/A	N/A	2017	The City of Sydney	Provides 437,000 jobs. Generates more than 25% of NSW's gross domestic product. Generates more than 20% of NSW's business waste. Provides grants and sponsorships to share economy initiates.	(City of Sydney, 2017c)
				Assets (including land) valued at approx. A$12.7 billion	(City of Sydney, 2017a)
20,000	Businesses		Businesses in City of Sydney		
169,056	People	2007	Residents in City of Sydney	N/A	(City of Sydney, 2017b)
187,690	People	2012			(City of Sydney, 2017b)
210,000	People	2017			(City of Sydney, 2017b)
200,000	People	2017			(City of Sydney, 2017c)
75%	%	2017	Total residents living in apartments	N/A	(City of Sydney, 2017c) (City of Sydney, 2018)
273,500	People	2031	Residents in City of Sydney		
260,000	People	2031		N/A	(City of Sydney, 2017c)

93,932	Dwellings	2007	Dwellings (households & homes) in City of Sydney	N/A	(City of Sydney, 2017b)
102,410	Dwellings	2012			(City of Sydney, 2017b)
115,000	Dwellings	2017			(City of Sydney, 2017c)
155,950	Dwellings	2031			(City of Sydney, 2017b)
1,200,000	People	Daily	Workers, residents, visitors and students	N/A	(City of Sydney, 2017c)
385,421	Jobs	2007	Employment in City of Sydney	N/A	(City of Sydney, 2017b)
437,727	Jobs	2012			(City of Sydney, 2017b)
557,760	Jobs	2031			(City of Sydney, 2017b)
N/A	N/A	2014-15	City of Sydney street cleansing crews	N/A	(City of Sydney, 2014-15)
N/A	N/A	2014-15	City of Sydney rangers	Perform at least 130 hours per month in proactive patrols of littering, waste, dumping and illegal advertising. In the fourth quarter of 2014-15, these patrols totaled 1,316 hours.	(City of Sydney, 2014-15)
N/A	N/A	N/A	The Environmental Committee of the City of Sydney Council	An internal council committee that oversees environmental concerns in the City of Sydney local government area and complies with NSW legislation.	(Sohkhlet, 2019)
N/A	N/A	N/A	C40 Climate Leadership Group (C40)	A group of 90 cities (including the City of Sydney) that collectively has more than 650 million citizens and represents 25% of global GDP.	(City of Sydney, 2017a)

N/A	N/A	N/A	Green Villages	Website produced by City of Sydney with home waste reduction resources	(City of Sydney, 2017c)
			Freecycle Network	Share economy initiative. A non-for-profit online platform enabling people to give and received free used goods in their own town. Founded in 2013, the organisation is registered in Arizona, USA. In the Sydney metropolitan area, there are 15 registered groups, with 45,000 members.	(James, 2019)
N/A	N/A	N/A	Garage Sale Trail	Share economy initiative. An annual event facilitating the sale of second-hand goods between neighbours in communities. Council participation costs A$238 per property, excluding staff wages.	(City of Sydney, 2017c) (James, 2019)
N/A	N/A	N/A	Reverse Garbage	Share economy initiative. A business which accepts second-hand goods, typically considered 'hard rubbish', packages or sells them on as a resource. The organisation also runs educational workshops with schools and other community groups.	(James, 2019)
N/A	N/A	N/A	Bower Reuse and Repair Centre	Share economy initiative	(City of Sydney, 2017c)
N/A	N/A	N/A	NABO	Community-based share economy initiative	(City of Sydney, 2017c)
N/A	N/A	N/A	Sell Buy Swap	Community-based share economy initiative	(City of Sydney, 2017c)
N/A	N/A	N/A	Open Shed	Community-based share economy initiative	(City of Sydney, 2017c)

N/A	N/A	N/A	Better Building Partnership (BBP)	Business and institution waste sustainability programs. A group of 14 members (City of Sydney one of those) who are leading commercial and public sector landlords who report progress on waste reduction and resource recovery to the City of Sydney annually	(City of Sydney, 2017c) (City of Sydney, 2017b) (City of Sydney, 2018)
N/A	N/A	N/A	CitySwitch	Business and institution waste sustainability programs	(City of Sydney, 2017c)
N/A	N/A	Year 2016	Closed Loop Environmental Solutions	Ran a trail program developing a business case for a coffee cup recycling facility, funded by the city of Sydney	(City of Sydney, 2017c)
N/A	N/A	N/A	Smart Green Apartments program	A City of Sydney program that works with 20 apartment buildings annually to reduce GHG emissions, water consumption and waste management.	(City of Sydney, 2018)
N/A	N/A	N/A	NSW Container Deposit Scheme	N/A	(City of Sydney, 2018)

3.3 Discussion and Conclusion

This chapter contributes to existing literature by being the first holistic study of an active waste management system in Sydney. It extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) by reviewing parts in the system (such as communication and public reporting) and their interconnected relationships, in addition to traditional waste diversion metrics used by the City of Sydney. Observations of the case study waste system and its existing 2030 zero waste

target identified vital gaps in public reporting, including: 1) poor communication of the target by the City of Sydney; 2) incomplete and conflicting publicly reported waste data by the City of Sydney; and 3) an absence of publicly reported waste data by other key stakeholders.

Communication of the waste reduction target poorly described the definition and approach was identified as both unnecessarily complicated and arguably misleading. This forms a significant barrier for stakeholders to make changes towards the very target itself; where understanding a shared goal can include and motivate change toward it.

One of the most concerning observations in this chapter was the scale of waste addressed by the formal zero waste target in the City of Sydney, which is a mere 10% of the total waste produced in the area. As discussed previously, if the case study 2030 zero waste target were to be achieved as proposed by the City of Sydney, it would only reduce the total waste produced in the local government area in 2017 and 2018 by 9%.[29] Not only is this scale poorly communicated to the public, but it is also not an isolated occurrence, for reporting commonly focuses on a relatively small scale of the total waste being produced in waste management more broadly. For instance, a Zero Waste Europe report identified that municipal waste was the most common waste indicator used by countries in the European Union; however, that waste stream only represents 10% of total waste production reported for that region (Wilts et al., 2019). Narratives like these around waste reduction are commonly presented through public channels as larger in scale than reality. They not only provide a false sense of achievement but shelter public forums from discussing larger scale system change. While any waste reduction is encouraged, a larger-scale impact is urgently required to address the environmental crisis the earth is experiencing, and transparency of communication can support the speed of that change.

[29] 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).

Incomplete and conflicting public reporting of waste data from the case study local government area was identified as a major barrier to target implementation and impact measurement; and therefore system change. This barrier was observed as exacerbated by a lack of supporting public reporting of waste data from any other key stakeholder. Conflicting data presented under different language over time, inconsistent measurements across different documents and an absence of reporting of waste movements or target reporting from the local government area (or any stakeholders) all impair accountability for progress against the 2030 zero waste target. These findings provide supporting evidence for work by Lamberton (2005) proposing that transparency, inclusiveness and auditability are required qualitative attributes for valid sustainability accounting. The gaps in reporting identified in this chapter were also consistent with observations by Brown (2016) regarding limitations in contemporary sustainability reporting, including: 1) the difference in units of analysis within and across organisations (here 'organisations' are internal reporting mechanisms), and 2) common lack of reporting concerning the costs, value and price of supporting non-financial data.

National public reporting is reliant upon accuracy, completeness and validity of data provided by the states and territories (Oosthuizen et al., 2019). While public reporting can equip stakeholders with information to push for political change (Oosthuizen et al., 2019), this is reliant upon the consistency of the information reported as well as how it is interpreted. For instance, while municipal waste is commonly used as an indicator for city waste production, it is not always the best indicator of the total contribution. Inaccurate public reporting from local government areas impacts the validation of state and therefore national public reporting on waste through data collection channels that inform the annual national waste reports. These reports shape parliamentary, and industry decision making. 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 for federal, state and local governments to understand the scale of landfill in their waste management systems. That

absence of reliable and completed data was also found to provide 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). The accuracy of public reporting on waste from local government areas therefore has much larger ramifications outside their geographic jurisdiction. This case study not only brings into question the depth of consideration and commitment to a waste reduction target in one local government area, but also the reliability of waste data being reported to higher levels of government that then informs system change.

3.3.1 Limitations and Suggestions for Further Research

There are two key limitations to this chapter. The first limitation was the availability of publicly available data regarding reporting and accountability of government waste management systems to analyse system change towards a waste reduction target. The second limitation was the lack of information in public reporting regarding social systems mapping, which is vital when human actors are involved in the system and can provide a more holistic assessment.

That the data required to assess the waste management system regarding its waste reduction target is not publicly available was both a finding of this chapter and a central limitation of replicability in following the work of Zaman and Lehmann (2013b) and Zaman (2014b). The scarcity of relevant texts regarding the waste reduction target that were available for review in the public domain needs to be explored further to understand factors impacting the public reporting of vital information regarding the city waste system in the City of Sydney waste management system. That includes public reporting from both government and industry, who have an opportunity to keep each other accountable in the public eye in regard to progress towards waste reduction targets. Additionally, government has a responsibility to publicly report back to its constituents in an appropriate manner that serves their safety and wellbeing (i.e.,

security of privileged information), while demonstrating progress towards targets they have publicly committed to. Many of the examples of poor communication identified in this chapter have no clear link to there being a security risk in privileged information; for example, the miscommunicating of target jurisdictions, the incomplete or conflicting waste data reported, or the unexplained projected budgeting of waste management practices. Constancy (Oosthuizen et al., 2019) and availability of publicly reported information about city waste management systems are required to provide a more holistic understanding of an active city waste management system. Future research could explore factors influencing the constancy and availability of publicly reported information regarding waste management systems in Australian waste management systems, and in cities specifically.

The lack of social systems mapping limited the research, as it did not provide information regarding the role of human actors in the city 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. When human actors in the waste management system share knowledge gained from a social systems approach, they can contribute understanding that is additional to traditional material analysis approaches and create a more holistic view of the system than either approach can alone. Through the inclusion of social system mapping in this holistic approach, factors influencing change towards the waste reduction target in this city could be identified and discussed. In the context of this limitation, Chapter Four explores the inclusion of social systems mapping in holistic approaches to city waste management systems, and together with the findings of this chapter, creates a more holistic city case study.

Chapter 4: Social Systems in City Waste Management Assessment

4.1 Introduction

Holistic approaches to waste management systems assessment require social systems mapping of human actors to provide richer understanding and identify factors impacting change. In this chapter, the need for social system mapping in holistic waste management assessment will be outlined, building on extant literature, and a case study featuring the City of Sydney's waste management system will be continued, as introduced in Chapter Three. This research will address the second objective of the thesis: to explore and describe key factors that may impact an active city waste management system attempting a waste reduction target transitioning towards its 2030 zero waste target. In doing so, it will contribute the first study holistic study of an active city waste management system in Sydney, as introduced in Chapter Three. It will also contribute the first holistic study of an active city waste management system in Australia that includes social system mapping of human actors.

A series of semi-structured interviews and focus groups were conducted to meet the second thesis objective. Fourteen factors impacting change in the city waste management system towards its zero waste target were observed in the knowledge sharing from participants, and were then grouped into 6 categories: 1) financing, 2) pivotal events, 3) communication, 4) physical surroundings, 5) leadership, and 6) local government employment. Social systems mapping identified factors that were not observed in publicly reported information about the city waste reduction target in Chapter Three of this thesis. These findings demonstrate the limitations of traditional reporting of

government waste management systems as an isolated approach by highlighting the insights that can be gained through social systems mapping.

Eighteen factors were observed across Chapters Three and Four as impacting change towards the city waste reduction target. These factors were considered together, and a conceptual model was developed to describe how these factors interact with each other in the city case study of a waste management system. The conceptual model features three interacting domains of change within which the factors sit: 'materiality', 'reporting', and 'sentiment'.

4.1.1 Holistic Waste Management Assessment Efforts and Limitations

During Chapter Three, the need for intervention regarding waste production was outlined, as was the requirement for holistic approaches (Zaman and Lehmann, 2011a) to be adopted into waste management system assessment. Through an analysis of reporting and accountability of government waste management systems, Chapter Three reviewed parts in the system such as communication and public reporting and their interconnected relationships, in addition to traditional waste diversion metrics used by the City of Sydney. Vital gaps were observed in public reporting while attempting to explore and describe an active city waste management system: 1) poor communication of the target by the City of Sydney 2) incomplete and conflicting publicly reported waste data by the City of Sydney; and 3) an absence of publicly reported waste data by other key stakeholders. These findings aligned with the unreliable and incomplete reporting of Australian waste management systems by local government previously identified by Jones (2020) and Qian et al. (2011). These reporting gaps from Chapter Three emphasised the need for social systems mapping to be included in a holistic approach when assessing waste management systems. Knowledge sharing by human actors in the waste management system, gained from a

social systems mapping approach, can contribute understanding to create a more holistic view of the system.

The impacts of waste on human health has been largely documented (Alam & Ahmade, 2013; Bourn et al., 2019; Chelsea M. Rochman et al., 2013; Giusti, 2009), drawing attention to the need to understand waste management systems in order to reduce the amount of waste entering control systems. While there has been increasing interest in waste management systems over the last two decades, those discussions predominately feature material flows and related social-economic quantitative data (Ben Madden, 2019; Dias et al., 2018; Díaz-Villavicencio et al., 2017; Hoornweg & Bhada-Tata, 2012; Pandey & Shukla, 2019; Shimamoto, 2019; Singh et al., 2014), or on social factors influencing system change largely driven by qualitative data (Ma & Hipel, 2016; Plata-Díaz et al., 2014; Wilson, 2007) without much overlap. Two key exceptions are the work of Zaman (2014b) and Chifari et al. (2018) who respectively propose holistic frameworks for understanding waste management system performance by leveraging quantitative data. Both Zaman and Chifari et al. recognise the role of humans in their work; Zaman (2014b) in a survey that asked stakeholders for reporting information, and Chifari et al. (2018) in a metabolic analysis of system inputs and outputs. The limitation of these two examples is the absence of human inclusion as social beings who interact with other parts in a system and act as factors influencing change. Neither paper was able to observe and engage with key factors that may alter moving elements in the active waste management system they are assessing. Seadon (2010) reveals a strong precedent for mapping the complexity of moving parts in a waste management system. This work takes a complexity approach in order to better understand change using the example of the Ministry for the Environment in New Zealand (Seadon, 2010). While Seadon's maps provide rich graphic representation of government projects, waste sub-systems, and stakeholders (Seadon, 2010), they do not explore human factors of change that influence that system map over time.

While holistic approaches to waste management assessment have been outlined by extant waste management literature (Zaman, 2014b; Zaman and Lehmann, 2013b), these processes are typically reliant on the avaliability of reporting on government waste management systems and do not include social system mapping; see Chapter Three. The nuanced complexity of factors influencing change in a waste management system cannot be fully understood solely through traditional reporting on government waste management systems. Including social systems mapping in a holistic approach to waste management system assessment aligns with the very intentions of a holistic approach: to acknowledge the relationship between all management levels and waste streams (Seadon, 2010). "Coordination of management between all levels and all waste streams" (Seadon, 2010, p. 1640) intrinsically includes human actors who generate, influence and manage waste in the system. A holistic systems approach that does not recognise the role of human actors is arguably not meeting the defining requirements of the label 'holistic'.

This chapter therefore extends the work of Zaman and Lehmann (2013b) and Zaman (2014b) who holistically assess city waste management systems using materials flows by including social systems mapping to produce a more holistic understanding. Together with Chapter Three, this chapter forms a rich city case study of a waste management system transitioning towards a waste reduction target. Section 1.1 will discuss the key concepts of social systems, and factors of change that frame the contribution to knowledge made by this chapter.

4.1.1.1 Social Systems

Systems allow the world to be viewed from a higher-order perspective, acknowledging the constantly shifting landscape around us. Like many concepts, the definition and application of a systems approach changes between users. Ackoff (1994) classifies systems into three: mechanical, organismic, and social. A mechanical system operates by an internal structure, whereby the whole and its parts follow causal laws (e.g., a clock) (Ackoff, 1994). An organismic system operates towards a purpose, whereby its parts hold purposes of their own, but together as

a whole form a purpose (e.g., survival) (Ackoff, 1994). A social system operates towards a purpose as well; however, some parts in the system have their own purpose and the system resides within other systems (i.e., nested) that have purposes of their own (e.g., societies) (Ackoff, 1994). While each of these system types can be helpful in understanding and observing system dynamics (i.e., patterns of movement in a system), systems in which self-aware organisms (e.g., humans or animals) interact can be best understood through a social system lens to acknowledge the purpose of those organisms as parts in the system. This perspective is supported by Ackoff (1994, p. 176) who claims that "systems in which people play an essential role cannot be well understood, hence managed, if viewed other than as social." This chapter therefore explores a social systems perspective to city waste management assessment to represent the human actors interacting in the system, and therefore provide a more holistic assessment of the city case study introduced in Chapter Three.

4.1.1.2 Criticisms of Previous Studies on Holistic Waste Management Assessment

The work of Zaman and Lehmann (2013b) and Zaman (2014b) on holistic waste management system assessment is primarily informed by avilable reporting on government waste management systems. Yet when Zaman and Lehmann (2011a) proposed a holistic model for a zero waste city in an earlier publication, they listed five principles that are directly influenced by human actors: 1) behaviour change and sustainable consumption; 2) extended producer and consumer responsibility; 3) 100% recycling of municipal solid waste; 4) legislated zero landfill and incineration; and 5) 100% resource recovery from waste. Again, the same authors published another list of key principles for a zero waste city (Zaman and Lehmann, 2013b) that are directly influenced by human actors: 1) awareness, education and research; 2) sustainable consumption and behaviour; 3) new infrastructure and systems thinking; 4) transformed industrial design; 5) 100% recycling and recovery; and 6) zero depletion legislation and policies. Each of the principles in these two publications by Zaman and Lehman can be linked to a human actor in

varying degrees. For example, behaviour change and sustainable consumption refers to decisions made by human actors in how they consider waste and in reducing activities that produce waste.

Despite the principles for a zero waste city listed by these authors as being directly influenced by human actors, the holistic assessments conducted in their zero waste studies do not include a social systems approach. Instead, Zaman and Lehmann (2013b) emphasise the efficiency of material flow in a circular metabolism as the primary indicator of performance by proposing the Zero Waste Index as a measurement tool. These authors acknowledge that waste diversion rate is a limiting performance indicator for waste management systems cities and argue for a more holistic approach, but the holistic approach they propose does not include a social systems lens. Later work by these authors applies the Zero Waste Index to a variety of city case studies such as Adelaide, San Francisco and Stockholm (Zaman, 2014b; Zaman and Lehmann, 2013b) and in once instance, provides an accompanying survey of waste management organisations and experts regarding motivations for zero waste activities and management priorities (Zaman, 2014b). This survey is, however, limited in its ability to reflect the role of human actors in the city waste management system as 1) it is a survey using multiple choice questions that does not support participants to share anecdotal evidence or knowledge in their own words; 2) it includes questions related to governance, policies and material flows rather than questions which would reflect how actors in the system understand and interact with the waste reduction target; and 3) it does not support dialogue or co-production of knowledge between participants and researcher that can be explored using other methods (e.g., interviews or focus groups).

This chapter therefore extends the body of work by Zaman and Lehmann by including a social systems lens in a holistic city waste management system assessment, building on Chapter Three. A series of semi-structured interviews and focus groups were conducted to explore how human actors understand and influence the city waste management system as it transitions

towards a waste reduction target. For more detail regarding the data collection and analysis of this process, see Chapter Two. Discussed in this chapter are the factors influencing change that were observed in the city case study of a waste management system. The observed factors provide a greater understanding of the city waste management system than was achieved through the desktop review in Chapter Three due to the limited publicly reported information available.

4.1.1.3 What are Factors and How do they Behave?

There are many ways to talk about system characteristics that influence change. For example: 'factors' (Plata-Díaz et al., 2014; Qian et al., 2011; Triguero et al., 2016); 'drivers of change' (Bartolai et al., 2015; Bulleri and Chapman, 2010); 'enablers and barriers' (Caldera et al., 2019); or 'barriers' (Dieckmann et al., 2020; Gifford, 2011; Govindan et al., 2014; Graham-Rowe et al., 2014; Painuly, 2001; Sorrell et al., 2004; Sorrell et al., 2011).[30] Of these examples, the concept of 'barriers' is commonly used to describe change; however this thesis uses the term 'factors' to best reflect change observed in the system. Section 1.1.2 will therefore describe each of the change concepts listed above and identify why the term 'factors' was selected for use in this research.

Drivers of change carries connotations of dynamism or intention for movement in the system, whereby the observed characteristic is personified to describe intention for change. While this is helpful to invoke an emotional response from readers, this phrase does not capture the objective nature of system characteristics, which are not conscious beings and therefore cannot purposefully make an action. Rather, it is the stakeholders within that system that make conscious decisions regarding change and 'drivers of change' cannot reflect this nature of social systems.

[30] Similar to the term 'factors' is the term 'indicators' that Zaman (2014a) uses. This term has not been included in the above discussion of terms because 'indicator' is used as a quantifier rather than a nuanced observation of system change (i.e., to measure change rather than describe the change itself).

Terms such as barrier and enabler also carry emotive connotations akin to 'positive' and 'negative' that can be polarising or present opportunities for hyperbole. They, too, do not reflect the nuance of a given observation, especially in social contexts where different stakeholders in the system may perceive the same concept or idea differently. Barrier, when used alone, fails to recognise any benefits that may be presented by the catalyst for change being discussed. While useful when exploring the perception of a system characteristic, this word would be inappropriate as an overarching term and therefore can be considered nested within drivers of change as a more specific classification type.

The term 'factor' has therefore been used in this thesis to address and acknowledge the varying or nuanced roles that characteristics of change may have in an active waste management system. Factors that bring change in waste management systems have been employed to discuss policy transition. For example, Plata-Díaz et al. (2014) identified factors influencing the structure of waste management policies, Triguero et al. (2016) identified characteristics of individuals that act as factors in waste management policy adoption, and Qian et al. (2011) identified 'explanatory factors' of social influences that impacted environmental management accounting in local government waste management.

While the language of 'factors' has been previously implemented in a waste management system context, their use is limited in an ability to communicate a holistic perspective. In Plata-Díaz et al.'s paper (2014) the key factors discussed remained at a high level under the labels 'economic' and 'political' that were not able to provide detail into system change dynamics. The paper was also limited in scope, where the research was directed at understanding the difference between forms of privatisation in the industry (Plata-Díaz et al., 2014). At the other end of the spectrum of specificity, Triguero et al.'s paper (2016) identified factors impacting an individual's acceptance of different waste management policies. Personal details such as gender, education level, occupational status, household size and living area were discussed as factors impacting

system change (Triguero et al., 2016). Therefore, where Plata-Díaz et al.'s paper (2014) identified very general and high level factors that did not provide sufficient holistic insight into the change in the system, Triguero et al.'s paper (2016) identified highly specific personal characteristics that do not communicate any wider contextual factors impacting change (e.g., policy or organisational pressures).

Falling between these two extremes of specificity was Qian et al.'s paper (2011) that identified a rich set of factors that shaped the system under study 1): social structural influences across three factors (housing a total of seventeen sub-factors), and 2) organisational contextual influences across another three factors (housing a total of fifteen sub-factors). The limitation of this paper is that interview questions were directed at environmental management accounting information items and did not allow space for a holistic approach that includes personal accounts that impact an individual's influence in system change. This study was also conducted with employees at 12 local government organisations in New South Wales and therefore excluded stakeholders outside of that organisation who play key roles in waste management systems (e.g., representatives from industry, academia and community). In reviewing 12 cases more broadly rather than one case study in great detail, the paper is also limited in it's ability to represent key details of a working waste management system. The number of councils represented in the sub-factors identified, ranged between 1-7 (average of 2.7) which limits the generalisability of the observed factors in the 12 New South Wales local governments.[31]

Despite these three key works exploring the role of factors in a waste management system context, factors have not yet been used to describe change in a city waste management system experiencing transition towards an ambitious waste reduction target. They are therefore introduced in this Chapter, extending the work of Zaman and Lehmann (2013b) and Zaman

[31] The average number of councils that aligned with a sub-factor in the Qian et al.'s paper (2011) was calculated at 2.7 as per the following: 85 total council alignments with sub-factors, divided by 32 total sub-factors identified.

(2014b) to include the social systems lens in a holistic approach to city waste management system assessment.

4.2 Results: Social Systems Mapping of a City Waste Management System

A series of semi-structured interviews and focus groups were conducted to provide descriptive evidence of the city waste management system as it transitions towards zero waste by 2030; see Chapter Two. These were conducted to provide insights into the system from a personal, individual perspective that could not be provided through publicly available texts alone. After rounds of iterative data analysis, a table of observed themes was generated to understand change in the city case study waste management system. This table included themes, sub-themes and descriptions and then shown during focus groups for feedback and development with participants, following the co-production of knowledge through participatory action research. A final table of eight themes was developed after this data analysis and participant consultation; see Table 4.1.

Table 4.1. Final (fifth) table iteration of emergent research themes

Main Theme	**Sub-Theme**	**Sub-Theme Description**
Achievability	Definition Dependent Achievability	Zero waste achievability is dependent on the definition of the user, and the definition itself is defined by ambition. *Note: zero waste ambition ⇒ zero waste definition ⇒ zero waste achievability.*
	Zero Waste Believers	Groups of individuals who believe that zero waste is fully achievable, and/or has already been achieved somewhere.
	Zero Waste Non-believers	Groups of individuals who believe that zero waste is not fully achievable, or near fully achievable.
Change	Available	The role of contextual structures to support individuals, communities or

Factors	Systemic Support	industries in sustainability work (e.g., policy, infrastructure, law, or marketing).
	Connection through Seeing Waste	The extent to which a person connects with sustainability through physical viewing of waste (i.e., links between seeing physical waste and one's personal life, experiences or leisure time; e.g., waste in publicly accessible marine and water ways, or visual media communication).
	Falsely Presented to the Public	The notion that zero waste is falsely presented as a concept to the general public.
	Not Transferable to the Public	The notion that zero waste is not always transferable conceptually or practically to the general public (i.e., in understanding or in physical ability to achieve it in their system context).
	Perceived Career Impact	The perceived impact sustainability work might have on a career (e.g., a political career trajectory).
	Pivotal Moment 'Bush Fires'	The notion that Bush Fires acts as a pivotal moment in time for stakeholders. Some felt this acted as a catalyst for increased environmental awareness.
	Pivotal Moment 'China Sword'	The notion that China Sword acts as a pivotal moment in time for stakeholders. Some feel that this moment is wielded as an excuse for our waste-related decisions in not taking advantage of the resources available.
	Pivotal Moment 'COVID-19'	The notion that COVID-19 acts as a pivotal moment in time for stakeholders. Some feel that this moment in time will alter the course of system waste management for varying reasons.
	Political Wedge between Stakeholders	A topic or concept used to create a divide between people which can either enrich a conversation or undermine another argument (i.e., a 'gotcha' moment). *Note: 'The Waste-to-Energy Divide' is an example of a 'Political Wedge'.*
	Publicity Driven Actions	The notion that an act towards sustainability is driven by potential for publicity.
	Role of Education	The role of past, current or future education impacts a stakeholder's actions in the system. (E.g., a lack of general education in a socio-economic area could impacts one's choices as a consumer, or a local government's educational program for a specific project impacting it's perceived 'success').

	Role of Financial Drivers	The exchange of waste and money generating financial factors between people, communities or organisation that do, or could, encourage change towards zero waste in the waste management system. (E.g., the use of a weight or volume to measure transaction between stakeholders which can be considered as an older style of measurement for zero waste).
	Role of Past Experiences	The role of past experiences with waste management systems that shape a person's current understanding of waste and their relationship to sustainability (these could be domestic or international experiences, cultural or habitual experiences).
	Role of Peer-to-peer Learning	The role of learning from the actions of those around you (i.e., existing street dumping influencing further dumping by others).
	Role of Political Drivers	The role of government legislation, agendas, contracts, political parties, or election terms in stakeholder decision making.
	Role of Social Drivers	The role of social norms, groups and expectations that influence stakeholder decision making.
	Self-praise-driven Actions	The notion that an act towards sustainability is driven by a sense of self-praise in 'warm and fuzzy' feelings.
	The Visible Face of Change	Who is at the forefront and visible in change regarding zero waste? (This might be an individual, group, organisation, etc.). *Note: Inversely, who is 'behind the scenes'?*
	The Waste-to-energy Divide	The concept or process of waste-to-energy being divisive across individuals, communities or industries and therefore linked with passion in discussion (e.g., in Europe it is commonly seen as a normal process for capturing energy; however, in Australia, it is not yet viewed as better than landfill despite the waste hierarchy).
Geography	Australia	As a country, more cynical and less responsive to government legislation than other countries like Germany.
	Europe	As a region, readier for change, rapid or slow, than other countries like Australia.
	Other	Another geographic region not otherwise listed as a sub-theme under the main theme of 'Geography'.

	Sydney	As a city, has a transient population (i.e., changing over short periods of time), impacting the design of education programs and the mindset of system stakeholders.
	United States of America	As a country, referred to for case studies and other anecdotal discussions.
Language	Bi-lingual or Multi-lingual Advantage	The advantage that a bi-lingual or multi-lingual person might experience in being able to think in different ways, unbound by one language structure.
	Communication Factors	The notion that English-speaking individuals, communities or industries experience time delays in translation of ideas and innovations from non-English-speaking areas work.
	Language Value	How much an individual, community or industry value's the language choices used for communicating sustainability work.
	Lexical Semantics 'Waste'	Use of the different terms in sustainability work, as deemed useful or relevant to the targeted audience (e.g., 'resource' in place of 'waste', or 'food scraps' instead of 'organics waste').
	Logical Semantics 'Waste'	Different conceptual understandings of the word 'waste'.
	War Imagery and Descriptors	Imagery, including terms and metaphors, with connotations of war have been used in discussing sustainability work which commonly holds negative connotations for audiences. (Alternative view, that the system is under pressure or stress, rather than experiencing conflict between sides).
Participant Background Context	Participant Employment or Education	Details regarding the participants' past or current employment, which may include the employing organisation, the role title and description. Details regarding the participants' past or current education which may include the housing organisation, the course title and description.
	Participant Reason for Work or Study	Descriptions as to why the participant decided to work or study in the specified area they are describing.
Scale of Change	Change Ratio	Both individual change and system change is required to achieve zero waste. The preferred ratio between these is dependent on the stakeholder.

		Note: Ratio of 'Individual Change' to 'System Change' ⇒ Stakeholder's Desired Outcome.
	Large Scale Change	Larger scale change that has not yet been identified as realised or actively undergone.
Waste Tools, Frameworks, Models and Concepts	Linear Economy	Participant perspectives on the concept or phrase, 'linear economy'. *Note: Commonly used to describe the current economy, heavily entrenched with consumerism and capitalism, in contrast with a 'circular economy'.*
	Waste Hierarchy	Participant perspectives on the concept or phrase, 'waste hierarchy'. *Note: Commonly used to describe the prioritisation of practices to minimise the 'waste' produced by a system and linked wit its corresponding upside-down triangle model.*
Zero Waste Definitions	A Goal or Target	Zero waste as something that can be worked towards, regardless of achievability.
	A Mindset	Zero waste as a way of thinking and linked with a call to action for society.
	A Resource	Zero waste as the considered use, retention or distribution of resources both physical and conceptual. *Note: This definition is linked strongly with circular economy in concept and language.*
	Circular Economy	Where zero waste is likened or in a relationship with a circular economy (sometimes referred to as 'circularity'). Note: Circularity is linked with future possibilities (e.g., dream-like or utopian future scenario) or exemplars identified at a local scale (e.g., case studies of existing communities).
	Confusing	Participant expressing their personal confusion regarding the definition of 'zero waste'. *Note: Participants who present this confusion of definition commonly ask the interviewer to answer the question for them.*
	Exists Between Moments	The notion that zero waste exists between moments in time (e.g. temporarily or ephemerally existing in years, or eras). Some consider zero waste to also be cyclical in nature across time (i.e., might occur or be achieved at different points in history ephemerally).
	Measurement	Where zero waste is used as a method of measuring waste passing between

		two points, or the discussion of ways to measure zero waste.
	Older Approach	The notion that zero waste is an older approach to talking about waste management aspirations. Some consider this to be 'surpassed' by circular economy.

The eight main themes highlighted on the left hand side of Table 4.1 were distilled into six factor categories that were identified as impacting change in the city case study waste management system; see Figure 4.1. These were selected by reviewing the themes and sub-themes in Table 3.4 and drawing out areas of discussion that were supported by both: 1) discussion across multiple participants, and 2) a direct connection with the city waste reduction target being assessed. These inclusion criteria were introduced to separate any irregular data that was not supported by other stakeholder anecdotes or evidenced data that was not directly addressing the research question.

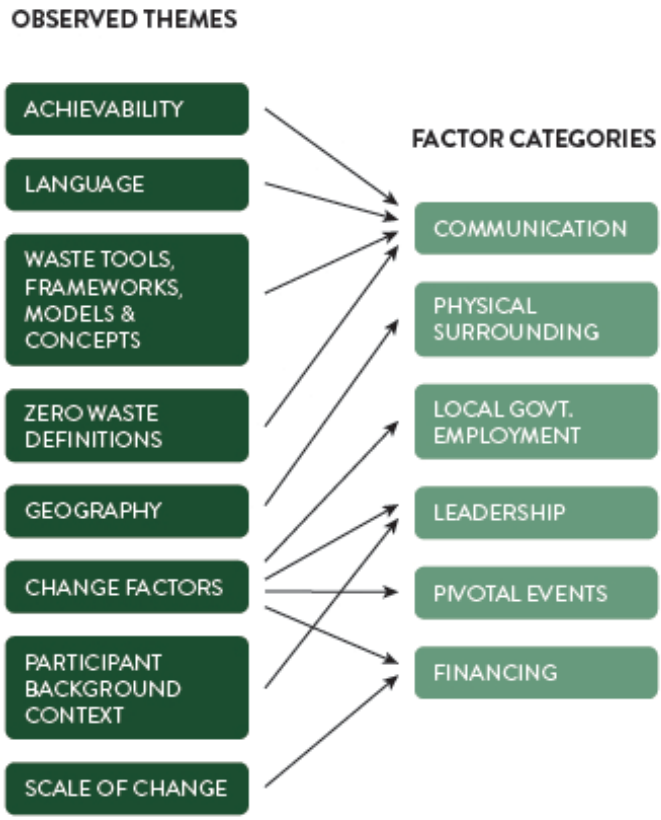

Figure 4.1. Development of factors' categories from themes observed in the data

4.2.1 Factors Impacting a City Waste Reduction Target

Fourteen factors were observed as influencing system change when exploring an active city waste management system attempting a waste reduction target. These are grouped into six factor categories: 1) financing; 2) pivotal events; 3) communication; 4) physical surroundings; 5) leadership; and 6) local government employment. These factors were derived from interview data where participants shared different perspectives on the same, or similar, concept (e.g., several participants discussed challenges of accessing or qualifying for government grants). Through this research, a greater understanding of a city waste management system attempting a waste reduction target can be achieved. This section will first summarise the six factor categories, then detail each of the fourteen factors that reside within them.

Financing influences change in the city waste management system through three factors: 1) low impact government grants; 2) risk-averse investing; and 3) stakeholder power of influence. As one participant observed, all waste management decisions in local government and private organisations alike are driven by finances (PN20). Government spending was perceived by participants as having a low impact on waste reduction targets where grants, levies and weight-based metrics are key points of concern. Risk-averse behaviour towards investing in waste reduction by governments and private organisations was discussed. Stakeholder power of influence on decision making in the waste management system was observed between local government and private organisations, as well as between private organisations and the public.

Pivotal events have the capacity to enact dramatic change in waste management systems and can impact the achievability of waste reduction targets. Three key pivotal events were observed by participants: 1) China Sword (2017–18); 2) bush fires (Sept. 2019–March 2020) and 3) covid-19 (Dec 2019–present). These pivotal events were characterised as changing Australia's waste management system and acting as a marker of time for stakeholders. Many participants spoke about these events in emotive and urgent language, with the descriptor 'crisis' commonly

used to discuss all three key pivotal events. While a singular pivotal event can impact a waste management system, and therefore zero waste, participants discussed how multiple pivotal events occurring in quick succession can collectively have an impact on the way Australians think about their behaviours relating to climate change and waste management (PN19, 23, 25). Additional domestic events such as flooding (PN16, 23), drought (PN25) and hail (PN16, 23) were also raised in the context of the impact of multiple events occurring in quick succession, with a collective impact on waste reduction attempts. Pivotal events in a waste management system could therefore not only impact the achievability of waste reduction targets individually but could have much larger roles when combined with other events in quick succession.

Communication was observed influencing change toward the waste reduction target across two factors: 1) poor target communication by the City of Sydney; and 2) varying target definitions across users. Participants shared their disappointment at the misleading nature of the waste reduction target and validated findings from Chapter Three; see Section 3.2. The ambiguity of zero waste provided a myriad of definitions from participants that aligned with boundary object behaviour (which will be discussed further in Section 4.3.1.1).

Physical surroundings were observed in the interviews and focus groups, where participants discussed the impact visible waste has on your emotional response to waste management. The connection between this emotional response and behaviour change is discussed as a factor influencing change towards the waste reduction target.

Leadership was observed influencing change towards the waste reduction target across three different factors: 1) progress towards target driven by respect for leaders in management roles; 2) lowered respect for leaders in management roles with higher education or management experience; and 3) lower workplace security with rotating leaders in management roles. These factors heavily foreground management as a key driver (and in some instances a barrier) for change toward the waste reduction target.

Local government employment was observed as impacting participants where the work culture shaped change towards the waste reduction target, and their ability to discuss the waste reduction target: 1) conflict of perspective between staff and their employer; and 2) the staff muzzle. Similarly to the factors discussed in the leadership factor category, this discussion links heavily to the impact of management when understanding change toward the waste reduction target.

4.2.1.1 Financing: Low Impact Government Spending

As one participant observed, all waste management decisions in local government and private organisations alike are driven by finances (PN20). Government spending was perceived by participants as having a low impact on waste reduction targets where grants, levies and weight-based metrics are key points of concern. Concerns were raised about the redistribution of funds raised through waste levies to other sectors, rather than reinvesting in the waste management industry to improve the system. One participant described how funds raised through waste levies enter a general finance pool and only a "fraction" is then allocated back into waste management (PN04).

Participants also questioned how effective or sufficient government grants are in relation to waste reduction (PN04, 13, 21) and noted that funding schemes like 'Waste Less, Recycle More' only fund capital costs, not staffing (PN13). Key barriers to accessing government grants identified by participants were highly specific selection criteria (PN09) and the amount of information required (PN10) to apply. For many smaller organisations, the amount of information required to apply for this kind of funding costs them more (in time, hired labour or investment) than the grant is worth should they be successful. This was described as a struggle for smaller or newer organisations where "if you needed the grant you couldn't qualify" and "if you didn't need the grant, well, in reality you qualify" (PN09). One participant proposed an

alternative, suggesting that funding be allocated in alignment with the waste hierarchy to primarily support reuse and recycling (PN18).

A lack of knowledge around tipping fees for an individual bin in residential waste collection and disposal was discussed. One participant outlined the process where councils are charged by the weight of a truck's contents upon tipping at a private facility (PN12). Despite this, an average cost per bin could be determined by the council by dividing the overall charge per truck by the number of bins collected in that route (and accounting for different bin sizes). This suggests that there is a lack of transparency from the council regarding the cost of tipping for each bin, rather than the lack of knowledge suggested by participants.

The factor of low impact government is therefore a combination of three characteristics: 1) the small fraction of waste levies income is redistributed back into the waste management system; 2) grants that are ineffective, insufficient in amount, and difficult for small or newer organisations to access; and 3) a disconnect between waste disposal charges paid by the council, and bin rates charged to residents.

4.2.1.2 Financing: Risk-Averse Investing

Risk-averse behaviour towards investing in the waste management system was identified across government and private organisations as barriers to change towards waste reduction. Firstly, local governments were described as risk-averse towards investment in waste reduction methods, programs, or technologies due to fear of constituent (voter) backlash (PN03, 20). This aligns with the previous discussion of funding generated through tax levies not being funnelled back into improving the waste management system (PN04); see Section 4.2.1.

Local governments were also described as prioritising budgets over waste reduction methods, programs, or technologies as they face challenges balancing constituent interests and financial stability as an organisation (PN05, 20). Agendas of local governments were described by one as being "often quite visionary" but lacking "the money to fund the really interesting

projects" (PN18). One participant discussed the pressure experienced by local governments, arguing that the government will not spend money "unless they've actually come up with a scheme that's shown to be perfect" (PN03). The second participant in the same interview then spoke of a "nightmare scheme" example of a commercial composter located in northern New South Wales that costs "millions of dollars" annually to maintain, yet is not working properly and therefore cannot be advertised or promoted publicly (PN02). This risk-averse governmental approach discussed by participants appears to be associated with a history of negative responses from constituents to changes made towards waste reduction targets. Here, the power dynamic of the government serving constituents inspires the desire for change while preventing action; thus, the democratic process curbs radical authoritarian change of any agenda.

Private organisations were described as risk-averse towards investment in New South Wales waste management to improve methods, programs, or technologies. The industry's lack of confidence in investing in the state's waste management was discussed; the NSW Environment Protection Association's (EPA) regulatory policy is perceived as "more strict than in most other countries" and "there's a real worry that council [resource] recovery rates are going down" (PN19). One participant discussed the inconsistent market for recycled plastics as a barrier, where private organisations do not want to invest in expensive processes that might not show a return on investment (PN05).

The factor of risk-averse investing is therefore a combination of three characteristics: 1) a fear of constituent backlash preventing local governments from investing in waste reduction methods, programs, or technologies; 2) local governments with waste reduction aspirations lacking sufficient funding for waste reduction methods, programs, or technologies and prioritising budgeting over change; and 3) private organisations in NSW having reduced investment confidence in waste management methods, programs, or technologies, due to strict EPA policies and low resource recovery rates.

4.2.1.3 Financing: Stakeholder Power of Influence

Stakeholder power of influence on decision making in the waste management system was observed between local government and private organisations, as well as between private organisations and the public. Waste management contracts issued by local governments to industry organisations were described as a barrier to change in the system towards waste reduction targets; local governments have less power in these relationships. Participants discussed the little control governments have over how industry organisations handle their waste (PN05), including the impact of Covid-19 on the economy, where "you can't really ask businesses to cut food waste right now when they're just trying to make money" (PN17). Waste management was discussed as having become about making "the most profit" (PN05).

A power imbalance was described as occurring when waste organisations in industry own the waste management infrastructure (e.g. landfills and recycling centres) and can present self-benefitting terms for any contracts with local government (PN12, 20), effectively "controlling the councils" (PN12). Financial drivers impact the length of these contracts. For instance, industry organisations need to take into account paying off loans for equipment (e.g., trucks) in the contract period (PN20); and re-negotiating terms and therefore, change in the system towards waste reduction targets, is difficult. Industry organisations therefore offer cheaper rates to councils for longer contracts (PN20) that provide financial security to invest in new technologies and equipment (PN21). Competition for these contracts between private organisations can be heated, particularly when smaller businesses reach a certain size (PN12). One participant talked about one such smaller company whose owner was threatened by one of the largest waste management companies (PN12). The influence industry organisations have over government decisioning making in waste management was raised, using the container deposit scheme as an example, where organisations pushed back against the program for 20 years so that they did not have to raise their product costs (i.e., price of a soft-drink bottle for consumers) (PN06).

The lack of transparency in public reporting of information about these contracts exacerbates the financial barriers to change in waste management and a power imbalance between local governments and industry organisations. One participant spoke about how the "commercial in confidence" nature of contracts between the local government and industry organisations contracted for waste management impacts the transparency in public reporting regarding: 1) who the contractors are; 2) where the waste is contracted; 3) the length of contracts; and 4) the volume of waste handled by these contracts (PN19). Collectively, the nature of government contracts with industry organisations for waste management (including contract construction) acts as a barrier to change towards waste reduction targets. Industry organisations have a concerning level of power over government decision making towards the waste reduction target through the structure and negotiation of contracts.

Participants discussed how the financial support of industry organisations influences public messaging about waste management practises towards waste reduction targets. For example, where industry organisations fund academic research (PN24), or where an individual owns both papermills and media outlets, thereby changing the public message about recycling based on the status of the papermill business (PN14). They also discussed how industry organisations were overcharging consumers for the collection and disposal of commercial waste, with a flat rate charged per bin regardless of how full it is – making "a fortune out of collecting air" (PN14). Public messaging, funding of environmental research, or ownership of both media and waste management companies provide concerning amounts of power over public perceptions of the waste management system; this then impacts the level of local government's public support for change towards the waste reduction target.

Public spending by consumers was also discussed as influencing the types of products and business models available on the market (PN05, 09, 15, 16). While public consumers were considered to have influence over the activities of industry organisations through how, when and

where they spend money, the scale of impact this has on industry organisations was not discussed.

Industry organisations were depicted as having a concerning level of power to influence local government decision making and public perceptions of the waste management system. This power of influence over key stakeholders in the waste management system can be used to manipulate progress towards the waste reduction target. Thus, despite public consumers having some influence over the actions of industry organisations, the descriptions provided by participants clearly outline the overpowering influence of industry organisations in city waste management.

4.2.1.4 Pivotal Events: China Sword Preventing International Waste Exports

'China Sword', 'China Ban' and 'China Reform' are phrases referring to China's 2017–2018 National Sword policy and Blue Sky program (Blue Environment, 2020; Downes, 2018; Staub, 2018). These policy changes impacted Australia's export of waste overseas, as China imposed a strict contamination threshold of 0.5% in waste imports that excluded the bulk of waste sold by Australian local governments (as domestic residential waste had a post-sorting contamination rate of approximately 6-10%) (Downes, 2018). As a large proportion of Australia's waste was being exported overseas, and in particular to China, this change became a defining moment for the nation's waste. In 2017, prior to these reforms, Australia had been exporting 29% of its paper and 36% of its plastics to China (Downes, 2018). This led to a domestic oversupply of waste and recyclable materials. The bulk of Australia's recycling infrastructure was no longer available, due to historic competition with overseas markets. Councils had a surplus of waste that could not be removed in the usual channels, leading some to stockpiling of waste or dumping of recyclable material into landfill. Recycled materials plummeted in value due to oversupply, with the average price of mixed paper scrap falling from A$124 per tonne to A$0 per tonne in February 2018 (Downes, 2018). As a consequence of Australia's response to the China Sword

policy change and the large media coverage on the topic, public confidence in the government's ability to responsibly treat waste was severely damaged.

International policy change impacting one of Australia's largest channels of exported waste appears to be a pivotal event in the waste management community. The China Sword policy change was raised by participants in two ways: 1) to explain an observable shift in Australia's waste management system (PN03, 04, 06), and 2) to discuss the negative impacts this event is having on Australia's waste management system (PN04, 05, 06, 11, 19). Emotive language was used when describing the impacts of China Sword, including descriptors of a "crisis" (PN06), where "the EPA in every single state in Australia has just been thrown into turmoil" (PN05). The perception implied that this event could impact the achievability of waste reduction targets that were in place prior to it. This connection was observed by one participant: "The impact of the China Ban on waste imports last year threw the entire country into a loop and, um, raised questions of whether or not people can achieve any of these targets that were set" (PN04).

The interruption of waste exports from Australia caused by the China Sword policy changes radically not only altered the function of waste management in the case study city, but created an urgent need for change to reduce waste production and improve domestic waste management systems. This pivotal event is often used as a point of reference by system stakeholders to consider how unpredictable change can disrupt typical material flows in waste management systems.[32]

4.2.1.5 Pivotal Events: Bush Fires Increasing Environmental Awareness

Bushfires in Australia between September 2019 and March 2020, known as the 'Black Summer', was a devastating event unlike previous seasons (Cook, 2021; Richards, 2020). It

[32] China Sword as a pivotal event may impact communication between groups of people, where assumed knowledge of the event might exclude those entering the system who were not impacted by that change at the time (e.g. expatriates or recent graduates).

resulted in 33 deaths, destroying 3,094 houses and burning over 17 million hectares of land (Richards, 2020). As a result of smoke inhalation across the country, there were an estimated 445 additional deaths, 3,000 respiratory hospital admissions, and 1,700 people presented for asthma, totalling an estimated $2 billion in heath costs (Hitch, 2020).

The 2019–20 bushfires' impact on the public perception of climate change as a threat appears to be a pivotal event in the waste management community. The impacts of this event on the waste management system appear to be primarily to public perspectives and behaviour change regarding climate change (and therefore waste reduction). Participants commonly discussed this shift (PN 16, 17, 19, 23, 25) with reference to the impact this might have on public behaviour change as a shock to the "normal day-to-day grind" (PN25). In some instances, these discussions featured hope for public behaviour change in the future in response to bush fires (PN16, 17). Heightened awareness of the impacts cause by human behaviour generated by events such as the Black Summer bushfires can impact the public adoption of changes towards waste reduction targets.

4.2.1.6 Pivotal Events: The Covid-19 Pandemic Increasing Medical Waste

The global pandemic of the novel coronavirus, known as Covid-19, is believed to have originated in China, where the first cases were publicly reported in December 2019 (Hawkins, 2020). The first domestic cases were publicly reported in Australia during January 2020 (Campbell, 2021; Hawkins, 2020). This global outbreak was officially classified as a pandemic by the World Health Organisation (WHO) in March 2020 (Hawkins, 2020). By May 2020, there were more than 4.6 million cases and 312,000 deaths reported globally (Hawkins, 2020). This pivotal event radically impacted ways of life and, therefore, waste management systems across Australia in all industries and homes. A study of waste data from eight local government areas in South Australia between 2006-2020 linked Covid-19 with increases in general (6.2%) and

organics waste production (20.9%) and was associated with more people working from home (Xu et al., 2023).

While the impacts of the three events discussed in these sections are still being experienced in Australia's waste management system, it is important to note that the Covid-19 pandemic began after the first round of interviews with participants (Australian Waste Management) and before the second round of interviews (Zero Waste in the City of Sydney). Covid-19 was therefore not mentioned by any participants during the first round of interviews (PN01-11) and only discussed in the second round of interviews in 2020, or in the subsequent focus groups. Sentiments shared by participants are therefore a reflection of perspectives held in the first few months of the pandemic.

Some participants discussed a chain-like impact of Covid-19 as a pivotal event on all Australian sectors and industries that has shifted societal norms (PN16, 23, 25).[33] In particular, participants discussed how Covid-19 has highlighted public awareness of Australia's dependency on international supply chains for resourcing goods (PN14, 19). This was discussed in relation to national vulnerability, where many domestic industries (e.g., agriculture and manufacturing) are no longer able to cater to all of Australia's needs independently (PN14, 19). Covid-19, as a pivotal event, could therefore impact the existing waste management systems that were considered when structuring waste reduction targets.

Covid-19 was discussed as impacting the type and location of waste generation in Australian waste management systems. Participants discussed the movement of waste generation from commercial and industrial sites to residential locations (PN21, 23, 26), and an increase in waste generation from medical industries (PN26). A shift in anticipated waste generation sources from past levels could impact existing waste collection contracts and the rate at which waste can

[33] An example of this societal shift in response to Covid-19 can was observed in the charity sector, which, as a consequence had: 1) fewer volunteers (P16); 2) storage demands for quarantining of donations (P16); 3) inability for regular home collections in and out of lockdowns (P16); and 4) increase of illegal dumping at charity sites (P17).

be processed in alignment with existing waste reduction targets. However, there were also participants who felt that Covid-19 would have no impact on the normal operations of their respective roles in waste management (PN20, 21, 22), or merely slow the process down rather than reshape the existing infostructure (PN22). The contrasting views regarding the impact of Covid-19 on existing waste management infostructure could reflect a lack of shared knowledge regarding waste collection data during the beginning of the pandemic. Gaps in communication and collaboration across the waste management community could impact the ability of stakeholders to work towards waste reduction targets in the presence or absence of pivotal events such as Covid-19.

Many participants also discussed the way in which Covid-19 as a pivotal event has impacted the priorities of the Australian public politically, where health and financial security are now more important that sustainability (PN16, 17, 22, 23). As these interviews were conducted during 2020, one participant shared the sentiment that "everyone is seeing COVID-19 as an issue of 2020 but not really any further" (PN22); this was echoed by another participant: "everyone's in, in a bit of a crisis mode trying to deal with the immediate" (PN16). This reprioritisation of public priorities politically could impact the level of change regarding waste reduction expected by the public from their political representatives and disincentivise individual behaviour change.

4.2.1.7 Communication: Poor Target Communication by the City of Sydney

There appears to be a belief in the waste management industry that the government does not clearly communicate zero waste and its application to the public. This was discussed by three participants (PN24, 25, 26). One participant discussed their disappointment in Sydney and Australian governments "enjoying the branding" of zero waste while pursuing incineration (PN24) which they feel does not fulfil the requirements of zero waste. Another participant commented that it was possible to market zero waste falsely to the public when it is not

disclosed that the term is commonly used by governments to refer to zero *avoidable* waste. In both instances, participants appear to be using their own definition of zero waste as a benchmark for how the government is performing. However, it is interesting that both appear to be identifying a lack of transparency in initial clear communication of a government definition of zero waste to the public. Additionally, the third participant (a consultant) noted a disconnect between the government actions and the formal documentation of work towards waste reduction: "the government's only paying us to do this paper that doesn't really change anything or give them a green tick, but they haven't really done anything great". This miscommunication (or misuse) of the phrase 'zero waste' could impact the success of applied zero waste targets in that governments may find it difficult to engage or inspire motivation for change in a public who do not understand the program. These insights present an ethical consideration: miscommunication of government achievements to the public could negatively impact the trust relationships between those communities and hinder waste reduction efforts.

EPA, landfills and councils were described as speaking about waste in terms of tonnes, due to the landfill levy in place (PN19). This was identified as problematic when waste materials are low in weight but high in volume; for example, polystyrene requires large amounts of space in a truck but is not financially valued as much as other heavier waste types (PN19).

These participant perspectives support the key findings identified in Chapter Three: gaps in public reporting in the City of Sydney's waste system and 2030 zero waste target. It is interesting to note that while findings from Chapter Three demonstrated the significant challenges to target implementation and impact measurement presented by miscommunication, this concept was not more broadly discussed by more participants in the interviews.

4.2.1.8 Communication: Varying Target Definitions Across Users

While the ambiguity of meaning conveyed by 'zero waste' was a catalyst for discussion and engagement, the definition and perception of 'zero waste' as a concept ranged across participants

(both in conversation with the researcher during interviews, and with other participants during focus groups). For example, when asked about the definition of 'zero waste' during interviews, participants responded using different combinations of common answers; see Table 4.2. Of these, there were five main definitions offered by participants: 1) goal, target or strategy; 2) mindset or perspective; 3) recourse/s; 4) diversion from landfill; 5) circular economy). These five key definitions were coded from interview transcripts where the keywords listed above were used by participants to describe their understanding of 'zero waste'. Of these responses, there was no dominant combination of definitions (where 'recourse/s' and 'diversion from landfill' were the most commonly combined definitions appearing together in the understanding of Participants 08, 09, 17, and 21). Additionally, there were three main perceptions towards said definitions: 6) ephemeral concept; 7) older approach; and 8) source of confusion; see Table 4.2. These perceptions towards definitions of 'zero waste' were more subjectively coded. The researcher identified notions of trends where; 1) 'zero waste' is ephemeral in time and only lasts a short while in use, 2) 'zero waste' was considered an old and outdated approach from previous decades that is no longer popular, or 3) that 'zero waste' was described as confusing to understand either themselves, or by others. These perceptions were not mutually exclusive as shown in the instance of Participant 23 who aligned with all three perception codes (an ephemeral concept that is an older approach and a source of confusion).

The apparent interpretation of the phrase zero waste was widely considered by participants to be simple enough for direct communication of an overarching ambition to the general public. This is despite the highly complex nature of the phrases' definition and the fact that its achievability has been continuously disputed within the waste management industry. It is this perceived simplicity that might be a key contributor to its usage throughout the waste management industry, both historically (primarily 1970s) and in recent years, where the phrase acts as an overarching, public-facing branding for a highly complex and often vague concept. In the example of the City of Sydney case, zero waste is communicated as a phrase to the general

public without an accompanying explanation of the two different targets set in place for the year 2030 (including the different levels of jurisdiction, budgeting and action available by the local government to achieve said waste reduction targets); see Section 3.2.1.1.

Table 4.2. Participant responses to defining the phrase zero waste

	Described Definition					**Perception of Definition**		
	Goal, Target or Strategy	Mindset or Perspective	Recourse/ s	Diversion from Landfill	Circular Economy	Ephemeral Concept	Older Approach	Source of Confusion
Participant 07	√	√					√	√
Participant 08			√	√				
Participant 09			√	√				√
Participant 10			√			√		
Participant 11			√					
Participant 12			√					
Participant 13		√					√	
Participant 14			√		√			
Participant 15								
Participant 16		√	√		√			
Participant 17			√	√	√			
Participant 18	√	√	√				√	
Participant 19		√						√
Participant 20	√						√	
Participant 21			√	√			√	√
Participant 22	√				√			√
Participant 23	√			√	√	√	√	√
Participant 24	√				√			
Participant 25				√				√
Participant 26				√				

4.2.1.9 Physical Surroundings: Waste Visibility Increasing Environmental Awareness

The ability to physically see waste appears to have an impact on an individual's ability to have a personal connection with their waste-related behaviour, which commonly inspires motivation for change. Participants commented that the ability to physically see waste has an

impact on the perceptions or actions of themselves or others. They gave examples of how individuals could see generated waste (PN05, 09, 10, 15, 22, 23, 26) or could not see generated waste (PN04, 05, 12, 19). Participants mentioned locations where waste is visible, such as: 1) bins 2) photos of landfills; 3) the television program War on Waste (Downes et al., 2019); 4) home environments (including indoors, council supplied bins, and a share-house); 5) work environments (including an office, a waste expo and a television show set); and 6) public environments (including a food court and parks). When discussing the inability to see waste (e.g., not seeing landfills, or environmental scientists not physically handling waste), participants commonly referred to a disconnect between cause and effect. Notably, one participant discussed waste that goes by train from the City of Sydney to Goulburn or sent offshore (PN19). This type of waste could not be seen as it is removed from its source of generation. Invisibility of waste could limit the ability for individuals to personally connect with their waste-related behaviour (including cause and effect) and therefore limits waste's ability to inspire motivation for changing those behaviours.

4.2.1.10 Leadership: Progress Towards Target Driven by Respect for Leaders in Management Roles

Leaders can have a role in inspiring motivation for change socially, and therefore have an impact on change towards waste reduction. The level of respect for these leaders in waste management was observed as impacting change towards waste reduction targets. Many participants identified individuals as leaders in waste management, using descriptors that reflected a shared community perspective of the person (e.g., "very well regarded", "the go-to guy", "the one who's always on TV", "always in the media", "the driver", "the leadership") (PN04, 06, 15, 19). This suggests that a leader in the waste management is identified as someone respected by the waste management community or public collectively. These types of individual leaders could impact the adoption of behaviour change among the waste management community or public in implementing waste reduction targets.

4.2.1.11 Leadership: Lowered Respect for Leaders in Management Roles with Higher Education or Management Experience

A level of respect was given to those in leadership roles in waste management who have worked with physical waste, compared with those entering the industry from a university pathway. Participants observed that many people entering the waste management industry in a management position, government role, or a position of power to inform change are university educated (PN12, 14). One participant disparaged university education, regarding the waste management industry as "the blind leading the blind", arguing that "they have no idea" because "they don't want to get their hands dirty" (PN12). While not including the role of universities, another participant discussed having worked physically with waste as a "value add" for management positions where staff "take you more seriously" (PN18). This participant also referred to a disconnect between management and "reality", describing staff "rolling their eyes" when "managers come up with a great new idea" (PN18). Heightened respect for those in leadership roles who have worked with physical waste could impact the industry, such that those entering from university pathways may face barriers to implementing change with their peers and staff.

4.2.1.12 Leadership: Lower Workplace Security with Rotating Leaders in Management Roles

Following the resentment towards leaders with higher education or management experience, was the observation that those individuals typically move between roles frequently, creating an unstable workplace. One participant identified this as a barrier to change, observing that these individuals typically switch "sideways" between private and public sectors when their career is blocked, without pushing for substantial change (PN14). Participant referrals to leaders in waste management revealed very recent staffing changes in key management roles such as:

"he's the head of, um... Well, actually no, he's not the head anymore, um..." (PN04),

"she worked with us. She had just had a farewell yesterday, actually." (PN06), and

"he has kind of, uhm, come in and he'd taken a, a very, uhm, a little bit of a different approach" (PN19).

The observations made of the data reflected the frequency of changing roles in the industry, and in particular the movement of key figures across organisations moving every few years across programs. This could acts as a barrier for change towards the waste reduction target in the work place where the constant change of leadership disrupts communities of practice.

4.2.1.13 Local Government Employment: Conflict of Perspective Between Staff and their Employer

In the waste management industry, the job security felt by an individual appears to have an impact on the amount of information that an individual is comfortable to share during the interview process. A local government council employee (PN19) expressed concern for how participating in this research might impact their job security. When discussing zero waste, this participant explained that their personal ethics and values do not always 'dovetail' with their employer's position (PN19). The participant offered to share either their personal position or the local government's position on questions asked. They noted that the local government's position would not commit it to "too many things that we [the organisation] haven't committed to" (PN19). Arguably a confusing statement, this anecdote reflected a contrast of perspective between the participant as an individual when thinking about the waste reduction target, and their employer. This can act as a barrier for change where the worker may be conflicted (or even paralysed to inaction) by disconnect of personal and organisational values.

4.2.1.14 Local Government Employment: The Staff Muzzle.

The job security felt by an individual appears to have an impact on the amount of information that the individual is comfortable sharing during the research. The observed concern for job security was discussed by one participant (PN19) (see Section 4.2.1.13) with a level of candour that was noticeably absent from interviews with other local government council employees (PN21, 28). Examples of this more reserved interaction in the other two interviews included: 1) listing council achievements; 2) pausing to consider answers prior to speaking; 3) acknowledging council perspectives to questions; or 4) answering with publicly available information. Those who are employed by (or whose work is funded by) this council were also typically more restrained in the level of detail offered regarding the inner workings of waste systems in the local government area, sharing dismissive statements about the council: for example, that the council was "leading the way" or doing "an awful lot" (PN17). The role of job security (or associated financial security) here could impact the level of transparency in information sharing from key government stakeholders, presenting a challenge for effective public reporting and collaboration for change. This may include not only local government staff, but the organisations they work with who received financial funding through local government grants or contracts.

4.3 Conceptual Model: Interacting Factors in a City Waste Management System

Together, the Chapters Three and Four in this thesis provide insight into eighteen factors that influence change towards a waste reduction target in the city case study. The desktop review conducted in Chapter Three revealed:

1. City of Sydney engagement: poor target communication (see Section 3.2.1.1),
2. City of Sydney reporting: conflicting and incomplete data (see Section 3.2.1.2), and
3. Stakeholder reporting: absent waste data (see Section 3.2.1.3).

The interviews and focus groups in Chapter Four revealed:

4. Financing: low impact government spending (see Section 4.2.1.1),
5. Financing: risk-averse investing (see Section 4.2.1.2),
6. Financing: stakeholder power of influence (see Section 4.2.1.3),
7. Pivotal event: China sword preventing international waste exports (see Section 4.2.1.4),
8. Pivotal event: bush fires increasing environmental awareness (see Section 4.2.1.5),
9. Pivotal event: the covid-19 pandemic increasing medical waste (see Section 4.2.1.6),
10. Communication: poor target communication by the City of Sydney (see Section 4.2.1.7),
11. Communication: varying target definitions across users (see Section 4.2.1.8),
12. Physical surroundings: waste visibility increasing environmental awareness (see Section 4.2.1.9),
13. Leadership: progress towards target driven by respect for leaders in management roles (see Section 4.2.1.10),
14. Leadership: lowered respect for leaders in management roles with higher education or management experience (see Section 4.2.1.11),
15. Leadership: lower workplace security with rotating leaders in management roles (see Section 4.2.1.12),
16. Local government employment: conflict of perspective between staff and their employer (see Section 4.2.1.13), and
17. Local government employment: the staff muzzle (see Section 4.2.1.14).

This thesis is the first to identify this set of factors that jointly explain how and why the City of Sydney is experiencing difficulty in achieving their 2030 zero waste target. When viewed together, Chapters Three and Four provide a rich, holistic perspective of a city waste

management system case study as it attempts a waste reduction target. By conducting the research of Chapters Three and Four in the same city waste management system, using different data collection methods, a more holistic perspective was achieved. Across Chapters Three and Four, only one factor was identified using both approaches: poor target communication (listed above as 1 and 10). The identification of this factor across both chapters of this thesis demonstrates not only the scale of impact that poor target communication poses in the waste management system, but also highlights the importance of using different methods to observe different factors of influence from different perspectives. Any data collection method across Chapters Three and Four in isolation would reveal only a partial picture of the waste management system, together contributing a more holistic understanding.

While previous research that argues for holistic approaches to waste management assessment relies on the analysis of available reporting on government waste management systems (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b) they do not include the social systems mapping required to understand other factors influencing system change. The factors identified in Chapters Three and Four contribute to this gap in the literature. As a result, this thesis is the first to not only present a holistic assessment of a waste management system in Sydney, but the first to contribute social system mapping to such a study in this region.

4.3.1 Three Domains of Change in the City of Sydney Case Study

Emergent links were observed between the eighteen factors identified across Chapters Three and Four this thesis. A conceptual model was developed to explain the change factors observed across the chapters and their interconnected relationships in relation to the city case

study's waste reduction target; see Figure 4.2.[34] This modelling process was informed by a series of attempts to graphically represent the city case study waste management system during data collection and analysis in this thesis; see Appendix B.

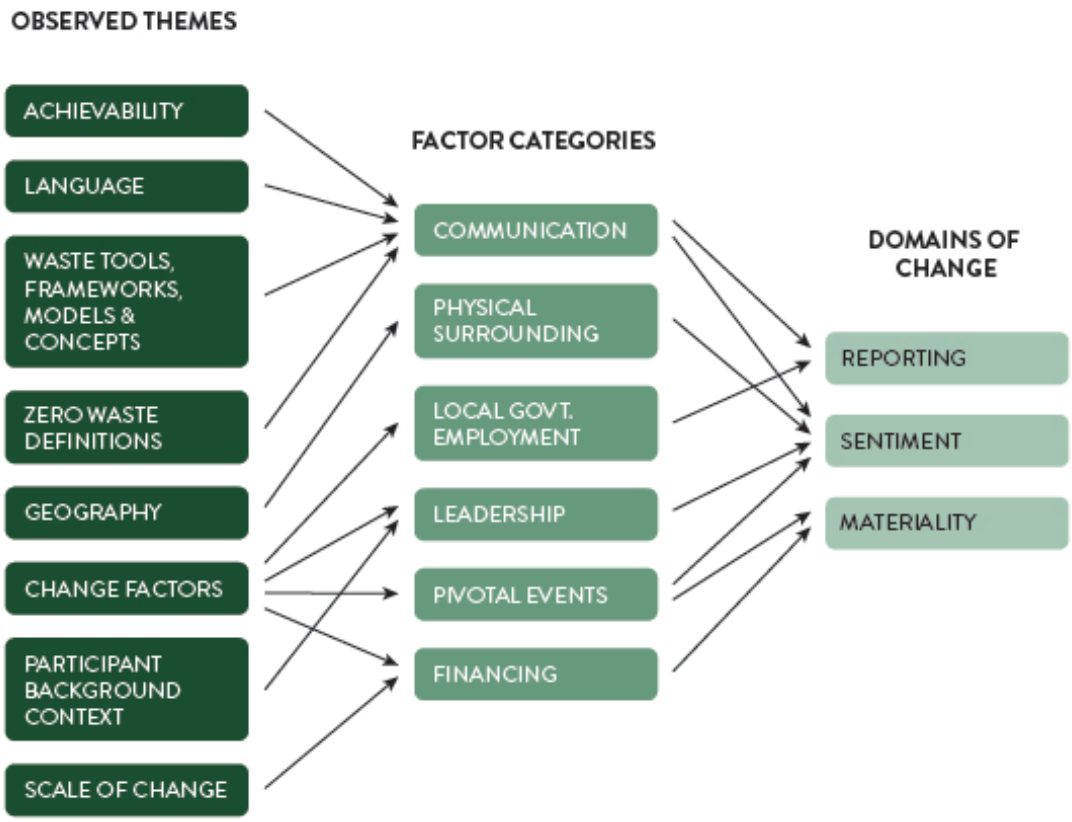

Figure 4.2. Domains of change development from factors' categories and themes observed in the data

[34] Please note: 1) that the eight 'Observed Themes' shown in Figure 4.2 are taken from the eight 'main Themes' that were highlighted in Table 4.1; and 2) that the six 'Factor Categories' are those discussed in Section 4.2.1.

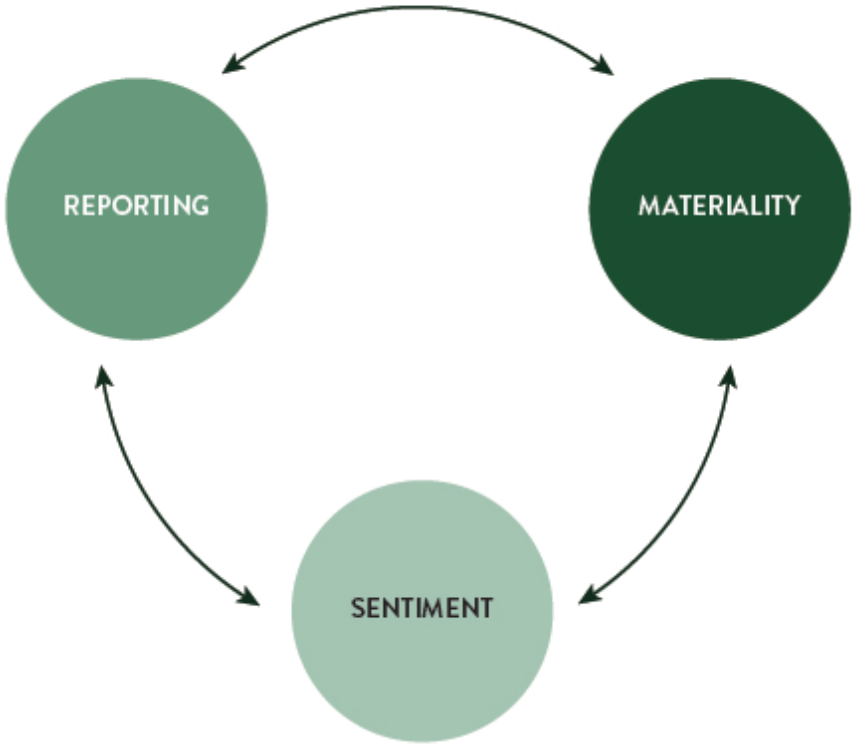

Figure 4.3. The three domains of change in the city waste management case study

Initially, the links between all eighteen factors were grouped into three interacting domains of change that influence the city waste management case study. The three change domains are 'materiality', 'reporting', and 'sentiment'; see Figure 4.3.

- **Materiality** refers to the quantity of solid waste and the types of mechanical equipment used in waste management that inform waste reduction towards the target.
- **Reporting** refers to information sharing through public reporting about the waste reduction target released by different organisations.
- **Sentiment** refers to the perception or emotional relationship that stakeholders in the system have towards the waste reduction target, and therefore their level of support for system change.

These domains of change are dynamic and interact with each other over time. They represent both the stable contents of material accumulated, reporting documented, and

sentiments felt during the model's construction (based on the research findings), but also represent the changing states of their contents over time.

Zaman (2014a) has previously presented seven key domains in zero waste management: 1) geo-administration, 2) socio-cultural, 3) management, 4) environmental, 5) economic, 6) organisational, 7) government and policy. The three domains of change identified through this thesis vary in scope and contribution to Zaman's work in several ways. Firstly, the seven domains identified by Zaman were distilled following a global literature review that was conducted to inform the design of a survey questionnaire. Being of global scope, the seven domains proposed by Zaman (2014a) are unable to reflect a working waste management system at a local government area level. The three domains of change present in this thesis are drawn from a case study of a city waste management system transitioning towards a waste reduction target. Consequently, the three domains of change in this thesis contribute to an understanding of more localised systems allowing for greater detail parts of the system to be explored.

Secondly, a complete list of literature reviewed to generate the seven domains of change identified by Zaman was not included in the paper to confirm the data types taken into consideration. The domains of change identified by Zaman (2014a) are then most likely also limited in an ability to convey social systems mapping as it was generated from existing literature that traditionally data in environmental management accounting exhibits a bias towards quantitative data. Alternatively, the three domains of change identified in this thesis were developed using a combination of learning from public reporting analysis in Chapter Three and qualitative analysis of engagement with system stakeholders in Chapter Four to present a more holistic representation of an active waste management system.

The three domains of change presented here in this thesis therefore address the call for holistic approaches to waste management assessment that adopt a systems perspective have been argued for in the extant literature (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b;

Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b) to improve understanding of waste management systems.

4.3.1.1 'Zero Waste' as a Boundary Object Between the Domains of Change

'Zero Waste' was observed acting as a boundary object and followed throughout this research project through a narrative journey to navigate the waste management system in the City of Sydney in relation to its waste reduction target. This boundary object was observed in the relationships between these three domains of change; see Figure 4.4.

A conceptual or physical item can be observed as a boundary object when people interact with each other through the use of the item while holding both shared and differing understandings of said item (Ewenstein and Whyte, 2009; Star and Griesemer, 1989). For instance, Benn et al. (2013) posit 'sustainability' as a boundary object example. While the term sustainability generally refers to the maintenance of the environmental ecosystem on earth, it can be understood differently between people. One person might consider sustainability an environmental ideal to work toward, while another might consider it a safeguarding of current behaviours going into the future. In such a situation, there are both shared and different understandings. While both perspectives include the maintenance of the environmental ecosystem on earth, one interpretation considers sustainability as a goal and the other as preservation. Neither is correct nor incorrect but a reflection of differing interpretations of an object. The simultaneous shared and differing understandings facilitate communication that tacks back and forth across boundaries of understanding without requiring consensus (Star, 2010; Zuzul, 2019); hence the name 'boundary object'. Understanding the foundation of objects (and therefore boundary objects) in the social science tradition will support understanding the role of zero waste as a boundary object in the conceptual model.

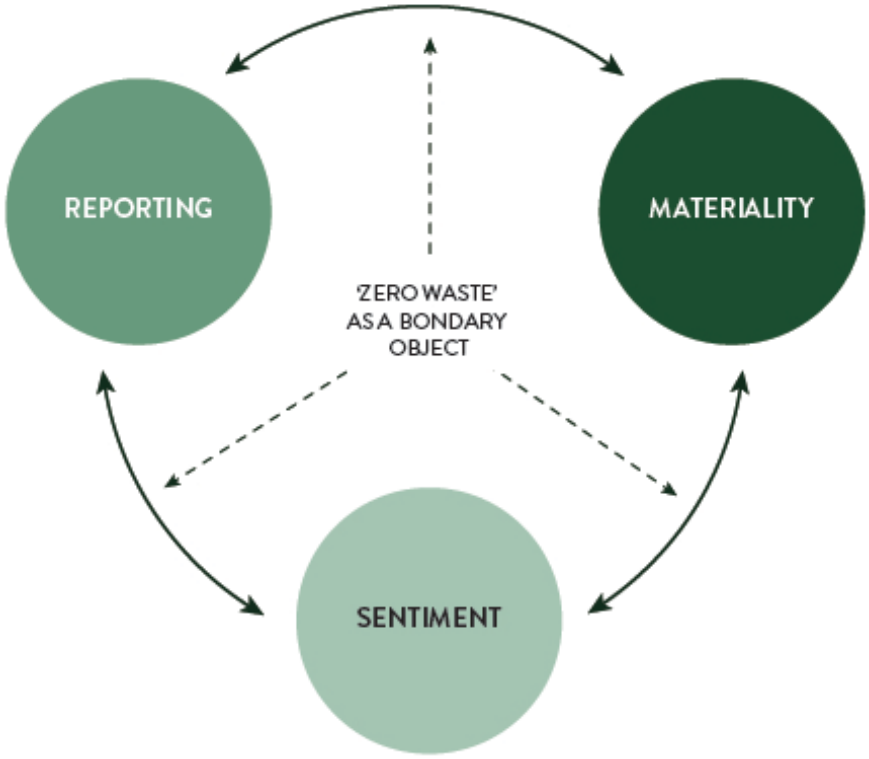

Figure 4.4. The boundary object of zero waste in the relationships between the three domains of change

The term 'object' in the social science tradition refers to a conceptual object (Star and Griesemer, 1989) that people act towards and with (Nicolini et al., 2012; Star, 2010). Objects are abstract (i.e., conceptual) and concrete (i.e., physical) items (Star and Griesemer, 1989) that, when observed, assist in understanding relational dynamics between stakeholders from different communities of practice.[35] The ontology of objects is historically focused on "becoming rather than being" (Ewenstein and Whyte, 2009), where objects are thrust into existence once observed rather than existing prior to conceptualisation (Star and Griesemer, 1989).

[35] For example, the idea of an item and its characteristics, function or role in a person's life could be considered an abstract, conceptual object. Meanwhile, a physical item and its appearance, tactility, accessibility, function or role in a person's life could be considered a concrete, physical object. While an object is not mutually exclusive in being either abstract or concrete (i.e., can be both simultaneously), objects can be observed in one form singularly (i.e. do not require both a conceptual and physical presence).

In many ways, abstract or conceptual objects become an extension of the body acting in the world. They can be assigned agency and human characteristics by individuals interacting with objects (Engeström and Blackler, 2005). It is through this extension of self that objects become catalysts for interaction with other people during communication or collaboration. "Objects allow us both to act at a distance and to make our interaction endure beyond the present." (Nicolini et al., 2012, p. 613) Four of the most commonly used object types in social science are:

- Boundary objects (Akkerman and Bakker, 2011; Benn et al., 2013; Benn and Martin, 2010; Carlile, 2002; Edwards et al., 2020; Enqvist et al., 2018; Ewenstein and Whyte, 2009; Montoya, 2017; Pilon-Summons et al., 2022; Star, 2010; Star and Griesemer, 1989; Wallsten, 2015; Zuzul, 2019)
- Epistemic objects (Ewenstein and Whyte, 2009; Nicolini et al., 2012)
- Activity objects (Nicolini et al., 2012)
- Technical objects (Ewenstein and Whyte, 2009).

Boundary objects are by far the most common object type and are discussed in relation to communication or collaboration between people. Where boundary objects differ from other object types is in their ability to cross boundaries between groups of people through both shared and differing understandings. Boundary objects can facilitate a shared understanding between social worlds and the generation of new knowledge (Benn and Martin, 2010). When under observation, boundary objects are stable in form, enabling communication or collaboration across social worlds while being interpreted differently by individuals (Ewenstein and Whyte, 2009). Interactions through boundary objects can act as translational devices (Nicolini et al., 2012), where a level of shared understanding regarding the object facilitates connection, while differing understanding enables debate and growth as the two groups converse; see Figure 4.5.

These interactions do not require consensus in the tracking back and between different forms of the object (Star, 2010); the object takes different forms as perceived by each social

world. Nicolini et al. (2012), for instance, describes how conflict in the context of observed boundary objects is visible, but resides in the background. Where differing understandings fuel interaction, boundaries between social worlds are heavily foregrounded (Nicolini et al., 2012). For example, Zuzul (2019) highlights the potential devise effects of boundary objects with two case studies of smart city projects (that were terminated before completion) where boundary objects were linked with systematic failure.

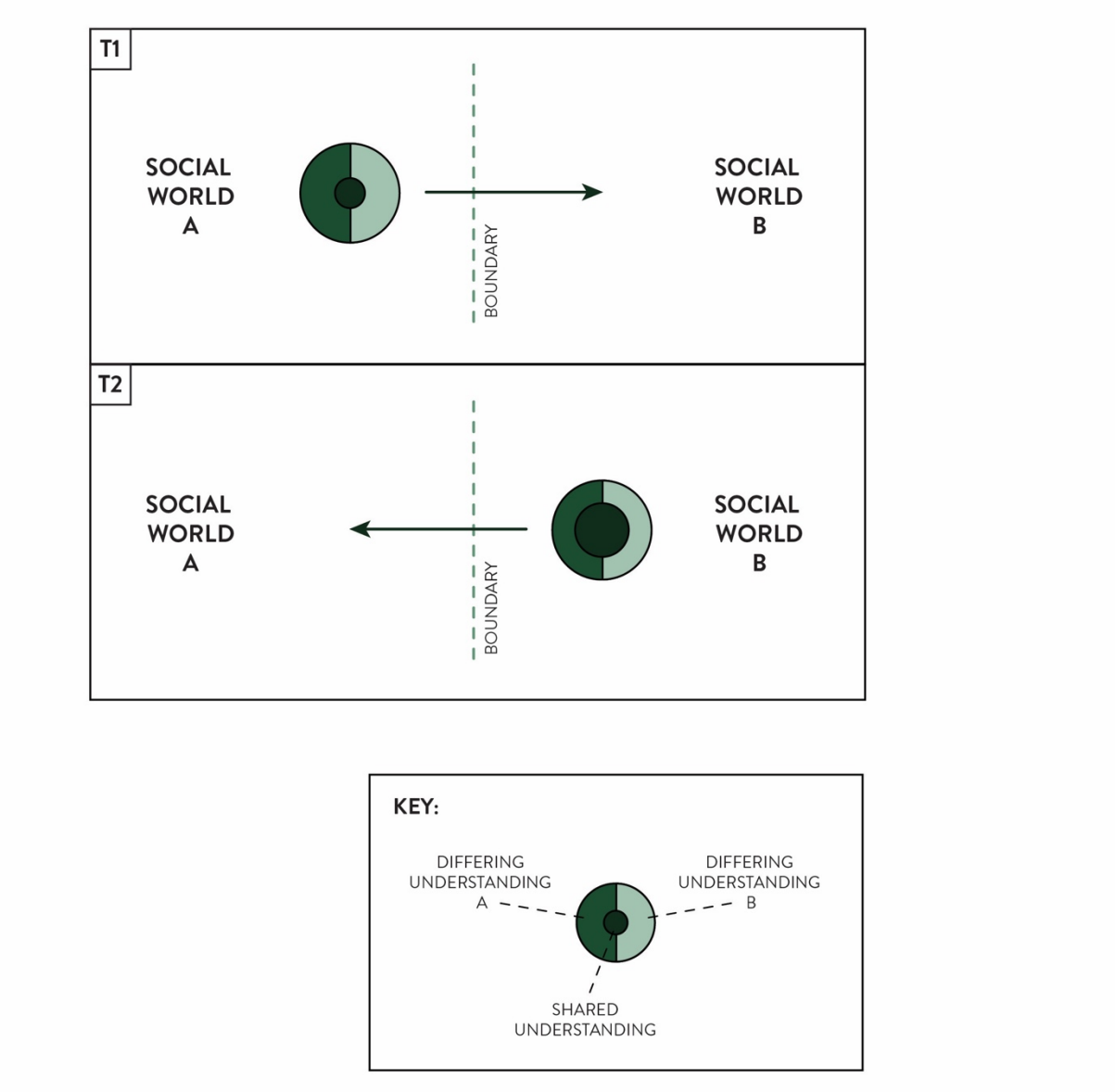

Figure 4.5. Boundary crossing of a boundary object

As outlined, boundary objects can be observed in conceptual objects (Star and Griesemer, 1989) such as: discourses, terms, concepts, processes, technologies, minutes, diagrams, models, or charts (Benn et al., 2015; Benn & Martin, 2010). Language, like boundary objects, can be considered a vessel for meaning, where the words we use to communicate are a medium between individuals. Terminology has been previously framed as a boundary object by Edwards et al. (2020) and Enqvist et al. (2018).[36] Additionally, project planning has been previously framed as a boundary object by Zuzul (2019). Following these pretendants, the 'zero waste' was framed as a boundary object driving this research; and featured in the conceptual model. Hannon and Zaman (2018) recognise the ambiguity of zero waste as a phrase; described as the combination of two terms that provoke a range of tensions to stimulate debate and innovation. The translation of meaning back and forth across boundaries through a boundary object (Nicolini et al., 2012; Star, 2010) may explain the longevity of zero waste as a concept spanning over decades; the constant negotiation of meaning attributed to zero waste without resolution maintaining communication between communities of practice.

The popularity of boundary objects has been criticised, where overuse of the concept can undermine its usefulness as an explanatory tool (Nicolini et al., 2012, Star, 2010). Others have argued that the simplicity of boundary object classification can distract researchers from the nuanced analysis of complex social interactions (Trompette & Vinck, 2009). As a result, Star proposed that boundary object framing is most helpful: 1) at an organisational scale; and 2) with a specific topic scope (Star, 2010). This has been addressed in the application of boundary object framing in this thesis where zero waste has been observed in both: 1) an organisational scale in exploring parts in the city case study's waste management system, and 2) a specific topic scale in exploring a waste reduction targets being implemented in a local government area.

[36] Terminology has been previously framed as an epistemic object by Rosenlund (2017).

Carlile (2002) outlines three characteristics of effective boundary objects: 1) language is shared or representative of the knowledge of people; 2) provides a catalyst for individuals to articulate and learn about their differences across a given boundary; and 3) facilitates the joint transformation of knowledge between participants. These are observed in the framing of zero waste as a boundary object in this research. 'Zero waste' as a phrase act as the shared language representing knowledge between people, where reviewed texts and recruited participants were gathered using the framing of zero waste. This language is both shared and differing, where participants were observed to define zero waste using different combinations of common characteristics (e.g., as a resource or as waste diversion from landfill); see Section 4.2.1.3. The catalyst for participants to articulate and learn about their differences across a given boundary were provided in the focus groups. These focus groups were designed to discuss the meaning of key terms and themes around zero waste in the city case study waste management system (as informed by findings in the desktop review and interviews conducted prior). The transformation of knowledge between participants was therefore facilitated by the participatory action research method applied to the focus groups (e.g., participant consultation over the table of emergent research themes, as discussed in Section 4.2). In alignment with the characteristics of effective boundary objects proposed by Carlile (2002), the role of zero waste as an active boundary object in the city case study of this thesis is outlined. This acknowledgment of zero waste as a boundary object in the City of Sydney waste management system provides a foundation to explore its behaviour through the conceptual model.

The phrase zero waste is exchanged across the materiality, reporting, and sentiment domains as a boundary object in the conceptual model; see Figure 4.4. In the relationship between the reporting and materiality domains, zero waste as a boundary object was observed in waste measurement. The phrase 'zero waste' tacks back and forth (Star, 2010) between the reporting and materiality domains where government reporting shapes the metrics that qualify

'zero waste' (i.e., diversion from landfill), while the waste quantity to landfill informs the needs for a waste reduction target. In turn, the financial value of disposed waste for the truck and landfill suppliers will change in relation to the zero waste metrics determined by government reporting where less waste may impact future income. Here the impact of zero waste on the two communities is vastly different; where the materiality domain will be directly impacted financially by zero waste. Therefore, the phrase zero waste crosses the boundaries of two distinct perspectives without consensus and could potentially transform into a conflict should zero waste be achieved (Zuzul, 2019).

In the relationship between the reporting and sentiment domains, zero waste as a boundary object was observed in communication about future planning. Zero waste provides an overarching ambition that government and industry bodies can manipulate to interact with the public; and, therefore, shape the sentiment domain. The level of genuine commitment and engagement of these organisations with the public in the pursuit of waste reduction is questionable. Regardless of intent, 'zero waste' as a phrase and concept quickly communicated a direction in which society can move. In these instances, messaging around zero waste as a concept driving a more sustainable future acts as a boundary object crossing between the reporting domain, to the sentiment domain (Star, 2010). The overarching ambitions of the target are used to engage the public and manipulate perceptions of the communicating body to present the appearance of change towards environmental values, regardless of intended action. For example, in a local government context, the perception of constituents towards its city shapes public opinions about the political party in power. While in the instance of a private organisation, the perception of the public shapes consumer engagement with a product.

While the boundary object of zero waste is then explicit for users in the reporting domain, they can be considered implicit for the public in the sentiment domain (Rosenlund, 2017); who are typically unaware of the manner in which the phrase is being manipulated as it crosses

boundaries of understanding between the domains. Unlike other domains where zero waste can be more loosely defined between users, the reporting context requires the application of strict measures to determine achievement towards a set waste reduction target. While clearly demarcated metrics appear on the surface to be a positive step towards achieving waste reduction, these metrics are commonly included in fine print additions or hidden in lengthy reports. The result is a public population who are typically unaware of the metrics that dedicate the success of the ambitious targets presented to them. Most of the public is unaware of the implications that a zero waste target carries, which is not in itself 'zero' waste. Waste reduction targets that carry the title of 'zero waste' are typically measured by the weight of waste diverted from landfill. Additionally, the diverted waste required to fulfill the zero waste mandate is commonly not 'zero' at all but a percentage of the overall waste disposal from the target start year. For instance, the City of Sydney's zero waste target calls for 90% diversion of solid waste from landfill between 2010-2030, see Section 3.2.1.1. The misleading nature of these fine print targets, whose achievements are never intended to reach zero, is problematic in reliance on any waste diversion metric at all. One could theoretically relocate waste from a city to a location other than landfill (e.g., a warehouse) and effectively attain 'zero waste' status without any attempt to reduce consumption or circulate resources back into the system. A weight-based metric is also unable to reflect the value of the objects being disposed of (e.g., resource reuse potential), nor the volume of the waste (e.g. polystyrene foam is high volume and low weight). Here, different communities across the domains therefore have differing perspectives of zero waste as a boundary object, while holding some shared understandings around the general supposed ambition (Ewenstein and Whyte, 2009; Star and Griesemer, 1989). Additionally, waste diverted from landfill as a metric draws attention is drawn away from changes to system dynamics that are required to reduce waste. For instance, active engagement with privatised waste management providers to collaborate towards the waste reduction target. Or alternatively, extended jurisdiction of local governments to influence waste reduction in the system. The City

of Sydney lacks authority to enforce the zero waste target that they have outlined for 90% of the area's waste (from residential, commercial and industrial, and construction and demolition sectors).

In the relationship between all three domains (reporting, materiality, and sentiment), zero waste as a boundary object was observed in technological intervention. The state of technological intervention within the materiality domain is impacted by the sentiment towards waste management, as driven by reporting from the government, industry and the media. Following the role of zero waste as a boundary object between these interdependent factors can be understood when the phrase 'zero waste' is given agency (Engeström and Blackler, 2005). When zero waste is compelling and attractive to the public eye, it becomes powerful as a communication tool in public reporting. In turn, the power public reporting wealds over political influence (through voting constituents) and can impact government funding into innovative technologies for waste management that may improve the success of a zero waste target. The phrase tacks back and forth (Star, 2010) between these domains in cycles driven by heightened media attention. One example is the War on Waste television show (Downes et al., 2019) which was cited by multiple participants in Chapter Three as a driver for increased media attention that spured the public's attention and consequently impacted a push for more environmental action in Australian politics; see Section 2.4.2.4 and 4.2.1.4.

While the framing of zero waste as a boundary object in this case study can assist in deepening understanding of the waste management system and its waste reduction target, the boundary object alone cannot fully explain the relationships between domains of change fully (Nicolini et al., 2012). Thus, while the observed boundary object is important for navigation and sensemaking in this conceptual model, it must be considered alongside other parts in the

conceptual model. Section 4.3.1.2 will therefore outline the role of components that house factors in the conceptual model.

4.3.1.2 Components within the Three Domains of Change

Each of the three domains of change contain different components that group the identified factors in a nested fashion; see Figure 4.6. These components have interactive relationships with each other inside these domains. Components in the materiality domain are: 1) 'waste quantity to landfill' that informs achievement towards the waste reduction target; and 2) 'the state of technological intervention' that supports waste reduction. Components in the reporting domain are: 1) 'government reporting' that demonstrates progress towards the waste reduction target; and 2) 'industry and media reporting' that provides supporting information to demonstrate progress towards the waste reduction target. Components in the sentiment domain are: 1) 'management of staff in government and industry' that motivates system change; and 2) 'public support for system change' actioned by organisations in government and industry.

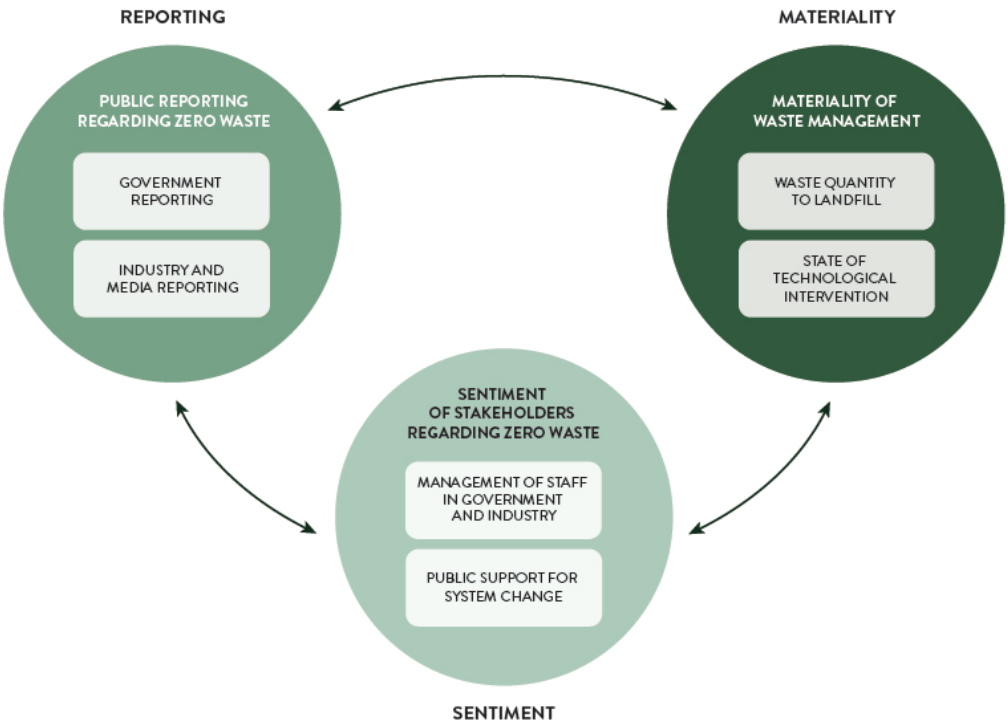

Figure 4.6 Interacting components within the three domains of change

Components within the domains of change have interactive relationships with each other. As this thesis takes a holistic systems approach to assessing city waste management, the behaviour of relationships between components in this conceptual model can be explained through system dynamics. Stemming from a seminal article by Forrester (1958), system dynamics describes characteristics of moving parts (i.e., constant change) in a system. These systems can be opened (i.e., influenced by parts outside of the system boundaries) or closed (not exposed to influence by parts outside of the system boundaries) (Ackoff, 1994). Influences impacting system dynamics are described by Richardson (2011) using two categories: endogeneity (i.e., from within the system boundaries) and exogeneity (i.e., from outside the system boundaries); see Figure 4.7.

The components in the conceptual model act as boundaries to create closed systems that relate and interact with one another across the three domains of change. For example, the components 'waste quantity to landfill' and 'the state of technological intervention' within the materiality domain are interdependent. The scale and effectiveness of technological intervention can impact the quantity of waste being sent to landfill, and vice versa, the quantity of waste going to landfill can inform the demand for technological intervention.

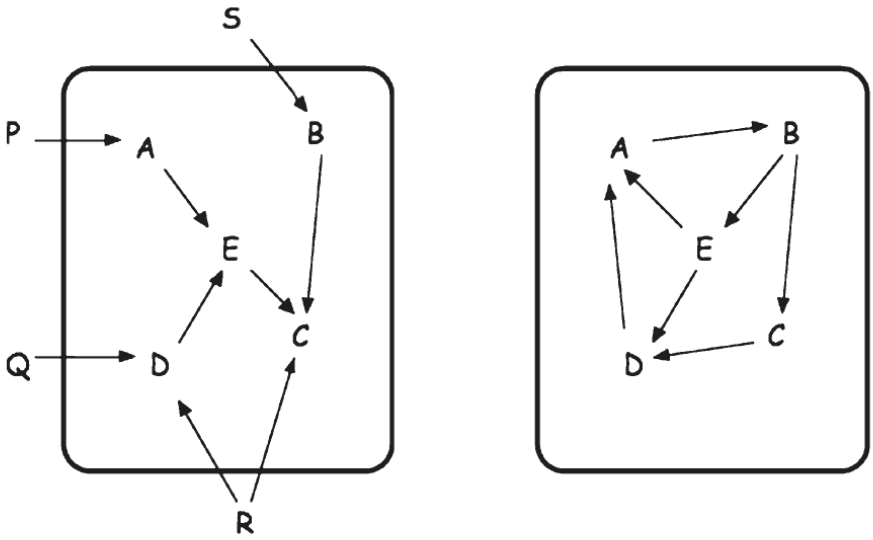

Figure 4.7. Endogeneity in practice; source, Richardson (2011, p. 222)*

* "Left: exogenous view of system structure; causality traces to external influences outside the system boundary. Right: endogenous view; causality remains within the system boundary; causal loops (feedback) must result."

4.3.1.3 Factors across the Three Domains and Components of Change

Within these domains and components, the eighteen factors influencing change in the city waste management system case study, which were observed in Chapters Three and Four; see Figure 4.8.

The waste quantity to landfill component contains two pivotal event factors: 1) 'China Sword preventing international waste exports', and 2) 'Covid-19 increasing medical waste'. The state of technological intervention component contains three financing factors: 1) 'low impact government spending', 2) 'risk-averse investing', and 3) 'stakeholder power of influence'.

Figure 4.8. Factors within the materiality domain

The government reporting component contains a City of Sydney reporting factor: 1) 'conflicting and incomplete data'. It also includes a local government employment factor: 2) 'the staff muzzle'. The industry and media reporting component contains a stakeholder reporting factor: 1) 'absent waste data'.

Figure 4.9. Factors within the reporting domain

Unlike other domains, the sentiment domain contains overarching factors that sit above the components. These include two communication factors: 1) 'poor target communication by the City of Sydney', and 2) 'varying target definitions across users'. It also includes a City of Sydney engagement factor: 3) 'poor target communication'. The duplication of poor target communication in these factors has been discussed as resulting from Chapters Three and Four of this thesis; see Section 4.3.

The management of staff in government and industry component contains three leadership factors: 1) 'progress towards target driven by respect for leaders in management roles', 2) 'lowered respect for leaders in management roles with higher education of management experience', and 3) 'lower workplace security with rotating leaders in management roles'. This component also contains a local government employment factor: 4) 'conflict of perspective between staff and their employer'.

The component referring to public support for the system change contains a physical surroundings factor: 1) 'waste visibility increasing environmental awareness'. This component also contains a pivotal event factor: 2) 'bush fires increasing environmental awareness'.

Figure 4.10. Factors within the sentiment domain

4.3.1.4 Conceptual Model of Change in the City of Sydney Case Study

Together, the factors, components and domains influencing change form a conceptual model that explains and describes how the city waste management system functions in the City of Sydney's transition towards a zero waste target; see Figure 4.11. Three domains of change are highlighted by the conceptual model reflecting the city case study. These three abstracted categories house the eighteen factors observed in this thesis and provide space to discuss the relationships between the grouped factors influencing change toward the waste reduction target. The reporting, materiality, and sentiment domains of this conceptual model interact with each other as inputs (e.g., consumables) and outputs (e.g., waste) engage with infrastructure, stakeholders and other factors of the existing city system. 'Zero waste' acts as a boundary object in these relationships between domains of change; see Section 4.3.1.1.

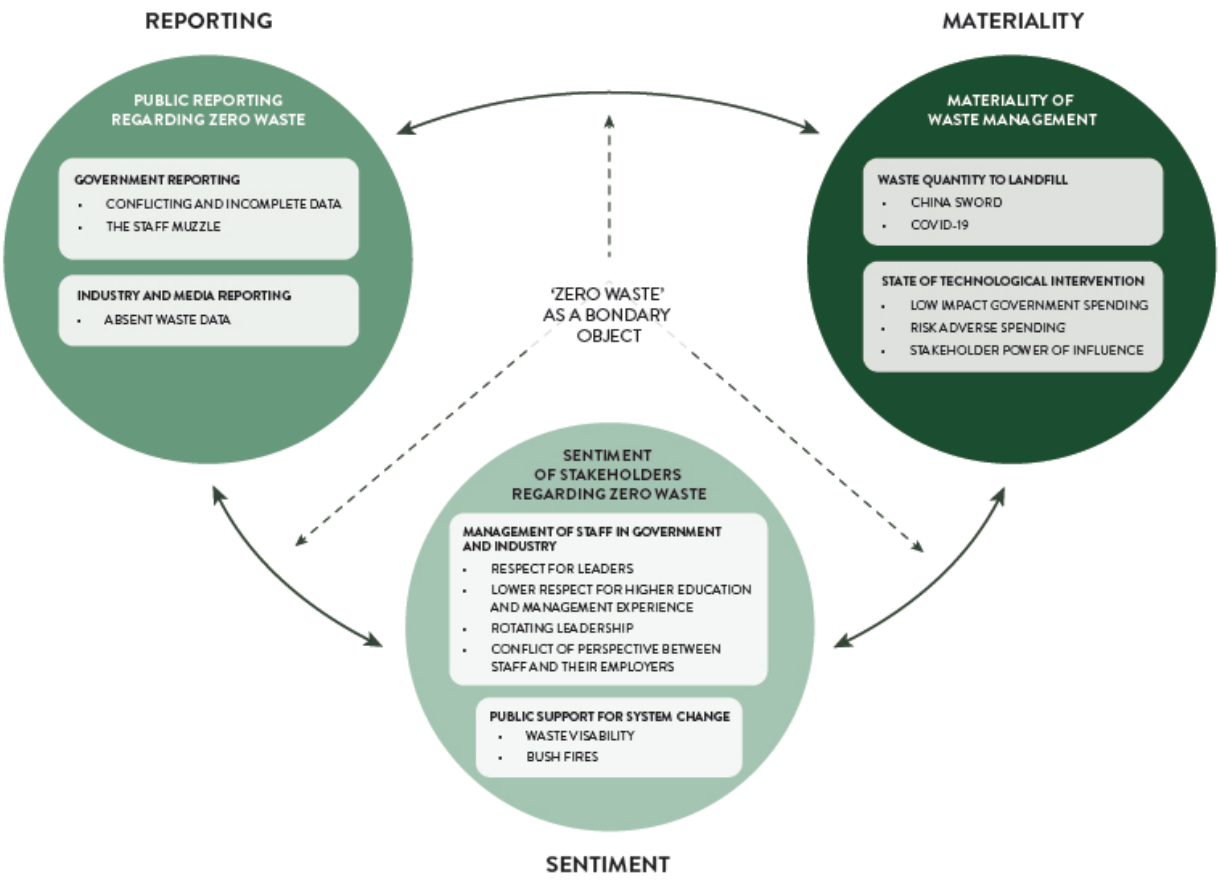

Figure 4.11. The conceptual model explaining and describing the city waste management system in the City of Sydney's transition towards a zero waste target

Understanding an active waste management system using a holistic approach is a difficult task due to the nature of constant change in real time, resulting in ephemeral characteristics and the potentially infinite amount of information required to ever know a system entirely. In the context of a waste management system, the difficulties of seeking understanding are heightened by the lack of both the required public information, and a drive to know said information. Significant challenges include poor government reporting, near absent industry public reporting and a lack of public engagement with waste as a topic that is uncomfortable and confronting to consider (outside the thrill of a media-heightened waste scandal). Yet waste reduction targets that do not understand the active waste management system in which they reside cannot address the needs of the very system they intend to improve. One might compare this to a plumber attempting to mend a home's leaking pipe without ever entering the building; or seeking assistance from those who reside within it.

The conceptual model in Figure 4.11 acts as a navigational device that aids the understanding of a complex system. The creation of the conceptual model throughout Chapters Three and Four of this thesis acted as a catalyst for developing an understanding of an active waste management system. Each stage of iterative reflection between data collection and analysis helped develop the eighteen factors featured in this conceptual model. Additionally, the final concept model provides an overarching abstracted perspective of the waste management system to translate the developed understanding of the complex system, simply. The navigational device proposed by the conceptual model is, therefore, both that of knowledge generation (through research) and translation. The conceptual model not only captures factors of change observed in Chapters Three and Four of this thesis, but prompts users to consider other factors in the system that are yet to be included.

In addition to the system navigation facilitated by the conceptual model, an opportunity is presented to reflect upon the contributions made by the different methods across Chapters

Three and Four in this thesis. It has been previously discussed that Chapter Three contributed three observed factors influencing change in the waste management system towards the waste reduction target, while Chapter Four contributed fourteen observed factors, see Section 4.3. The spread of these factors across the domains of change shows that the three factors from the Chapter Three contributed primarily to the reporting domain (and one in the sentiment domain), while the fourteen factors from the Chapter Four contributed primarily to the sentiment domain, then the materiality domain (and one in the reporting domain). This spread of findings representation across the domains of change may be the result of the methods used in each chapter. The desktop review in Chapter Three is likely to have observed more factors relating to the reporting domain as it primarily reviewed government reports. Interviews and focus groups in Chapter Four were likely to have observed more factors relating to: 1) the sentiment domain due to the human experience shared by participants during data collection, and 2) the materiality domain due to the anecdotal discussions of past experience shared by participants who have worked in waste management (often industry or government) and experienced the limitations of physical changes to the system. The way in which these factors contributed varying factor types reinforces the value of combining different methodological approaches to create a more holistic understanding of the city waste management system. Should only one of the chapters been conducted in isolation, the findings would be limited in: 1) the number of domains identified, 2) the richness of observations made within each of these domains, and therefore 3) the level of understanding gained about the waste management system.

Table 4.3. Spread of factors from Chapters Three and Four across the domains of change

Chapter	Factors	Reporting	Materiality	Sentiment
Chapter 1	City of Sydney engagement: poor target communication			√
	City of Sydney reporting: conflicting and incomplete data	√		
	Stakeholder reporting: absent waste data	√		
Chapter 2	Financing: low impact government spending		√	
	Financing: risk-averse investing		√	
	Financing: stakeholder power of influence		√	
	Pivotal event: China sword preventing international waste exports		√	
	Pivotal event: bush fires increasing environmental awareness			√
	Pivotal event: the covid-19 pandemic increasing medical waste		√	
	Communication: poor target communication by the City of Sydney			√
	Communication: varying target definitions across users			√
	Physical surroundings: waste visibility increasing environmental awareness			√

	Leadership: progress towards target driven by respect for leaders in management roles			√
	Leadership: lowered respect for leaders in management roles with higher education of management experience			√
	Leadership: lower workplace security with rotating leaders in management roles			√
	Local government employment: conflict of perspective between staff and their employer			√
	Local government employment: the staff muzzle	√		

4.4 Discussion and Conclusion

Observations made throughout the series of semi-structured interviews identified key factors impacting change in the City of Sydney waste management system towards its zero waste target: 1) financing, 2) pivotal events, 3) communication, 4) physical surroundings, 5) leadership, and 6) local government employment. These findings highlight stakeholder perspectives on system characteristics and aid in the identification of areas where the system can be improved. From these factors (in combination with the factors observed in the Chapter Three) a conceptual model was developed to assist in navigating system change in the city case study's waste management system relating to its waste reduction target; see Section 4.3. The conceptual model featured three domains of change: 1) materiality; 2) reporting; and 3) sentiment. 'Zero waste' as a conceptual boundary object was observed crossing boundaries between the domains of change and crossing boundaries of understanding (Star, 2010).

The importance of target communication, public reporting and financing in the waste management system was highlighted through this research. These complexities are acknowledged when understanding a waste management system through the lens of holism (Seadon, 2010) that are absent from traditional waste management assessment processes (that focus on waste weight measurement). This supports criticisms of traditional waste management assessment by Zaman and Lehmann (2013b), where waste diversion rate as a key metric was deemed inadequate and limited in forecasting ability (Zaman, 2014b). It also provides a precedent for an alternative method to holistically assess a waste management system that can be replicated in different waste reduction targets. This addresses the limitations of existing tools like the Zero Waste Index by Zaman and Lehmann (2013b), which cannot be used with other waste reduction target types and does not include social system mapping. The process of navigating a waste management system using a participatory action research approach facilitated this holistic exploration of a waste management system through loops of planning, acting, observing and reflecting following Kemmis et al. (2013). Emergent findings were therefore observed in co-production with participants utilising role reversal (Argyris and Schön, 1989; Baum et al., 2006; Kemmis, 2006) to enact social system mapping (Ackoff, 1994) to better understand system change in the city case study toward a waste reduction target.

Clarity of communication from the government to the public regarding waste reduction target ambitions and progress could improve the relationships with communities who can assist change towards said targets. Continued and increased exposure to the visible sight of waste in the media and lowering the disconnection individuals have with their own waste production could prompt behaviour change as well as encourage individuals to support larger system change towards these targets. Regarding financing, an increase in available government funds allocated to waste management and accessibility to those funds for waste reduction are needed. An overarching national strategy for waste management (including transport, contamination rates and resale) could assist in developing system resilience to endure pivotal events. Leadership by

those in positions of power can support others to make changes towards the reduction targets and develop trusting long-term professional relationships in a community of practice. Governments could better support staff who are eager for change towards their waste reduction targets to feel comfortable voicing their opinions or ideas in a manner that can push the institution's own agenda forward (i.e., include and more effectively use the resources of knowledgeable staff).

4.4.1 Limitations and Suggestions for Further Research

The factors selected for discussion in this chapter were chosen for their relevance to the second research objective and frequency of quotes across the participants (i.e., topics commonly raised across the interviews). Therefore, the impact of those factors discussed less frequently or related more tangentially is not acknowledged. Many other factors not identified in the data collection could also be considered, including: 1) perspectives of stakeholders not invited to participate whose work is tangentially related to, or impacted by, the waste reduction target; 2) perspectives that participants did not feel comfortable sharing or were unable to share (i.e., commercial issues in confidence); 3) factors in the waste management system that interviewed stakeholders were not actively aware of during the interview period.

Another limitation of the research is the subjectivity allowed to the researcher during thematic analysis to interpret and categorise the information shared by participants. This was addressed in part by presenting the first themes table to participants in the focus groups for discussion to support the validity of observed trends; their feedback informed iterations of the themes for this chapter.

While the identification of key factors impacting an active city waste management system attempting a waste reduction target in this chapter provides rich insights and contributes to a more holistic approach, it does not provide scope to investigate the role of language. This

chapter began to highlight the importance of communication between stakeholders, particularly from the government to others, as outlined in Chapter Three and echoed here. Understanding the role of communication in this context could support change in city waste management systems towards waste reduction targets. Observed use of phrases such as zero waste and circular economy during this research suggest the potential presence of a boundary object, where a physical or conceptual thing can be interacted with across communities of practice and cross barriers to collaboration.

Chapter 5: Conclusion and Implications

5.1 Thesis Conclusion

This thesis set out to observe and understand characteristics of an active city waste management system in transition towards a waste reduction target, using different disciplinary lenses to address the meta-research question, "What does system change in city waste management look like when undergoing a waste reduction target?" and two objectives arising from that question. Firstly, in Chapter Three, a holistic assessment of public reporting on the city case study's waste management system was undertaken and observed three key challenges in implementing and measuring its waste reduction target. Then, in Chapter Four it holistically assessed the city case study's waste management system with an emphasis on social systems mapping and observed fourteen factors that were grouped into six overarching categories: 1) financing, 2) pivotal events, 3) communication, 4) physical surroundings, 5) leadership, and 6) local government employment. Together Chapters Three and Four formed a case study that explored an active waste reduction target being implemented in a large metropolitan city: zero waste by 2030 in the City of Sydney local government area. A conceptual model was then created, utilising the eighteen factors observed across Chapters Three and Four to describe how these factors impacting the waste reduction target interact with each other in the city case study waste management system. The conceptual model featured three interacting domains of change: materiality, reporting, and sentiment.

5.1.1 Thesis Findings and Contributions to Knowledge

Waste production continues to grow internationally (Hoornweg et al., 2013; Hoornweg and Bhada-Tata, 2012; Nwachukwu et al., 2017) at rates that cannot be fully contained by extant control systems. The impacts of waste on human health have been documented (Alam & Ahmade, 2013; Bourn et al., 2019; Chelsea M. Rochman et al., 2013; Giusti, 2009) and cities as spaces of incredibly dense populations with complex waste management systems (Hoornweg and Bhada-Tata, 2012; Zaman and Lehmann, 2013b) are on the frontline of waste reduction. While many cities internationally are attempting waste reduction targets, few are achievable, clearly communicated, or fulfilled to completion. The relatively recent field of environmental management accounting has begun addressing these needs (Adler et al., 2022; Ha and Mansi, 2023; Lewis, 2000; Qian et al., 2011) however more holistic approaches to waste management assessment that adopt a systems perspective are required (Hannon and Zaman, 2018; Seadon, 2010; Zaman, 2014b; Zaman, 2015; Zaman and Lehmann, 2011a; Zaman and Lehmann, 2013b). Holistic approaches can improve understanding of waste management systems to inform change towards more sustainable practices.

The research conducted across Chapters Three and Four contribute to knowledge and therefore understanding in how waste reduction can be supported for more sustainable futures to emerge. Together they addressed the meta-research question "What does system change in city waste management look like when undergoing a waste reduction target?".

Chapter Three set out to address the first objective of this thesis; to explore and describe an active city waste management system undergoing a waste reduction target. The resulting research contributed a holistic study of an active waste management system. Chapter Three acts as both a case study for analysing reporting and accountability of government in a city waste management system context and is the first such assessment to be undertaken in Australia's most highly populated city, Sydney. In exploring and describing an active city waste management

system attempting a waste reduction target, three key challenges to target implementation and impact measurement were observed. Firstly, communication of the target by the City of Sydney, including a complicated and poorly communicated zero waste target. Secondly, conflicting and incomplete publicly reported waste data by the City of Sydney, including waste quantities, budgeting and transport. Thirdly, an absence of publicly reported waste data by other key stakeholders (such as contractors, partner organisations or non-for-profits) that may have been able to address city public reporting gaps previously observed. These findings informed the development of eight proposed design principles for improving city waste reduction target strategies globally, see Section 5.3.2.

These findings are of importance for the City of Sydney, other stakeholders in the local government area, and internationally for other cities attempting waste reduction targets. Quality reporting is vital in communicating planning and progress towards a waste reduction target and can act as a defence against the kind of misinformation and miscommunication that can radically impact a system change. The relatively small scale of municipal waste compared to the outputs of most cities (Wilts et al., 2019) is misunderstood by both the general public and other decision makers. Attention on the relatively small contributions of municipal waste compared to other sources distracts from the largest waste contributors; industries. Construction and demolition, commercial and industrial private organisations that contribute the most waste are not required to publicly report their waste in Australia (and therefore don't). Local governments have no jurisdiction over the waste of these organisations and the increasing privatisation of Australian waste management appears to give these organisations increasing power in decision making that informs federal and state policy. Transparent, inclusive and auditable reporting following Lamberton (2005) are required for well-informed sustainable change to occur in the waste industry.

Chapter Four set out to address the second objective of this thesis; to explore and describe key factors that may impact an active city waste management system undergoing a waste reduction target. The resulting research builds on the research in Chapter Three by contributing social system mapping of human actors in the holistic study of an active waste management system. Fourteen factors were observed as influencing system change when exploring an active city waste management system attempting a waste reduction target. These are grouped into six factor categories. Firstly, financing influences change in the city waste management system through three factors: 1) low impact government grants; 2) risk-averse investing; and 3) stakeholder power of influence. Secondly, three pivotal events have the capacity to enact dramatic change in waste management systems and can impact the achievability of waste reduction targets: 1) China Sword (2017–18); 2) bush fires (Sept. 2019–March 2020) and 3) covid-19 (Dec 2019–present). Thirdly, communication was observed influencing change toward the waste reduction target across two factors: 1) poor target communication by the City of Sydney; and 2) varying target definitions across users. Fourthly, physical surroundings were observed as a factor in instances where visible waste triggers an emotional response and therefore behaviour change with regard to the waste reduction target. Fifthly, leadership was observed influencing change towards the waste reduction target across three different factors: 1) progress towards the target driven by respect for leaders in management roles; 2) lowered respect for leaders in management roles with higher education or management experience; and 3) lower workplace security with rotating leaders in management roles. Finally, local government employment was observed as impacting participants where the work culture shaped change towards the waste reduction target, and their ability to discuss the waste reduction target: 1) conflict of perspective between staff and their employer; and 2) the staff muzzle.

While there has been increasing interest in waste management systems over the last two decades, those discussions predominately feature material flows and related social-economic quantitative data (Ben Madden, 2019; Dias et al., 2018; Díaz-Villavicencio et al., 2017; Hoornweg

& Bhada-Tata, 2012; Pandey & Shukla, 2019; Shimamoto, 2019; Singh et al., 2014), or on social factors influencing system change largely driven by qualitative data (Ma & Hipel, 2016; Plata-Díaz et al., 2014; Wilson, 2007) with little integration. Chapter Four of this thesis addressed that gap by presenting the findings on reporting from Chapter Three, together with the role of human actors in the waste management system.

The conceptual model presented at the end of Chapter Four provides a rich insight into the nature of system change in the city case study context when transitioning towards a waste reduction target, see Section 4.3. Contained within the three domains of change observed (materiality, reporting, and sentiment) were factors that influence the city waste management system transitioning towards a waste reduction target. The phrase 'zero waste' was observed acting as a boundary object in the relations between the domains of change. These system dynamic insights are informative for stakeholders in the system under study to improve local processes, and hold larger ramifications for the nature of materiality, reporting, and sentiment in other waste management system contexts. Application of this conceptual model to other contexts may provide a lens to highlight movement and exchange (or the lack thereof) between the domains of change (materiality, reporting, and sentiment) in different cities attempting waste reduction targets. Academics, practitioners, and key stakeholders in waste management systems can adopt this model to gain insight into communication, power dynamics and other factors in their own contexts that may impact the performance of a waste reduction target.

Methodologically, this thesis makes a number of contributions. Firstly, it provides a precedent for transdisciplinary philosophical perspectives to be utilised for research in the context of waste management systems, see Section 2.2. This context is historically siloed by organisation type (industry, government, academia and other communities). Chapters Three and Four unveiled a number of challenges faced by this industry for both reporting, and social systems mapping that can be supported through transdisciplinary philosophical perspectives to

include more holistic data for greater system understanding. This field could benefit significantly from the practice of combining perspectives and methods from different traditions utilising transdisciplinarity to achieve a greater understanding of a topic than can be achieved by any one perspective alone.

Secondly, the typology of participatory action research proposed in Chapter Two addresses a gap in the literature and, to the author's knowledge, is the first both proposed and utilised, see Section 2.3.1. The typology building on the three differentiating characteristics of participatory action research following Kemmis et al. (2013) and thirteen sub-characteristics developed from a literature review can be utilised as a resource by academia and practitioners looking to inform how they conduct community engaged research, see Table 2.2. Historically, the application of participatory action research has been described and executed differently across users. Existing textbooks, papers and guides to applying participatory action research are typically long, vague or inconsistent across texts. A typography like that developed in this thesis can quickly convey the key characteristics and sub-characteristics to those: 1) new to working with the approach, 2) being asked to be a participant in this kind of approach with no prior knowledge of the process, or 3) those looking to improve the rigour of their approach (with the understanding that this typology reflects an ideal application and not all projects are required to action each sub-characteristics to be classified as participatory action research).

5.2 Thesis Limitations and Delimitations

As in any research, there are a number of limitations to this thesis that therefore impact the insights drawn from findings. These include: 1) time and scope (including the impact of the Covid-19 pandemic and associated restrictions), and 2) bias of disciplinary background and personal perspective.

Firstly, this thesis began in August 2018 and continued through till the end of 2022. As a result, the research was heavily impacted by the Covid-19 pandemic, predominantly, the associated restrictions, lockdowns and stay at home orders mandated by the Australian (national) and New South Wales (state) Governments. This impacted the way the researcher, supervisors, and participants could interact, as well as their health and mental health during long-term confinement or isolation. Communication was heavily reliant on phone or zoom throughout this research and limited the relationships developed through the work (and therefore what individuals felt comfortable sharing in that format, where it is more difficult to build relationships between people). The demands on people's time and radical system change in response to this event changed workload demands and therefore availability of those participating (and for some, prevented their participation in the research). While the Covid-19 pandemic had the most impact on this thesis, the bushfires and floods that occurred during this period also impacted those involved in the research (either directly or contextually).

The conscious or unconscious bias of the disciplinary background and personal perspective presented by the researcher, supervisors and participants involved in this research inevitably impact the research design, data collection, analysis and discussion of findings. Due to the very definition of unconscious bias (i.e., bias one is unaware of), it cannot be discussed here, but it is important to acknowledge those predispositions or prior knowledges, which, while not articulated, impact the research nonetheless. Conscious biases of disciplinary background and personal perspective were present throughout the research and therefore necessarily impact the final thesis.

Disciplinary background (or field of work) shaped the approach of researchers and supervisors to this research, as well as shaped the interaction types of participants in the interviews or focus groups. This was addressed in part by the research design through the use of transdisciplinary and participatory action research approaches to fuel collaborative learning across these boundaries (e.g. actively inviting participants from across academia, industry and

government). Despite this, there are distinct disciplinary perspectives represented here that shape the work produced (e.g. accounting, environmental science, and social sciences).

The personal background of participants was not factored into the recruitment process, where individuals were invited to participate based on their relationship with zero waste in their work. This includes characteristics such as gender, race, age, and political views, which were not asked about in alignment with ethical considerations (and university ethics procedures). As a result, the demographics of participants including diversity of representation cannot be discussed in relation to the insights gained from these interactions and how these different perspectives altered the narratives shared (i.e., influencing the findings of this thesis).

5.2.1 Suggestions for Future Research

The findings of this thesis suggest or inspire the direction of four areas for future research: 1) the application of the research approach and navigation principles in other cities; 2) the analysis of the remaining factors observed but undiscussed in this thesis; 3) the impact of the thesis findings in the case study city local government area; and 4) the role of boundary objects in other sustainability fields.

5.2.1.1 Research Approach and Navigation Principles Application in Other Cities

The validity of the developed theoretical framework could be further explored through the application of the navigation principles across different city contexts to further iterate and strengthen its reliability as a generalisable resource. Further research in this area could include the observation of a city during implementing of this framework from the beginning of a waste reduction target to completion, in order to better understand the role of such navigation principles over time.

Having outlined a transdisciplinary and holistic case study in this thesis, future research could feature the replication of this approach to other unique city systems undergoing (or planning to undergo) transition towards a waste reduction target, including the application of the seven navigation principles developed in this thesis. This could inform change and progress towards said targets as well as provide further descriptive evidence for the requirement of holistic approaches to city waste reduction targets (i.e., more inclusive than waste weight data alone). Potential cities that could be included in this future research might be others who, alongside Sydney, have signed C40's 'Advancing Towards Zero Waste Declaration' (C40, 2019): Auckland, Boston, Catalonia, Copenhagen, Dubai, London, Los Angeles, Milan, Montreal, Navarra, New York City, Newburyport, Paris, Philadelphia, Portland, Rotterdam, San Francisco, San Jose, Santa Monica, Stockholm, Tel Aviv, Tokyo, Toronto, Vancouver, Wales & Washington, D.C. Other waste reduction target types outside of zero waste, such as circular economy, could also be investigated. The research approach and proposed navigation principles from this thesis are not directly tied to zero waste specific waste reduction targets.

5.2.1.2 Impact of the Thesis Findings in the Case Study City's Local Government Area

This thesis has (or will) impact the case study city through intervention in the waste management system during the research. Two primary intervention events have occurred (or will in the near future): 1) when interacting with stakeholders as participants during interviews and focus groups, and 2) upon formal confirmation of the thesis when the thesis is shared back to participants of the research. Future research could include an impact study seeking to observe change in the city waste management system as informed by the process and findings of this work. This might include reengagement with the participants of the interviews and focus groups, or focus more closely on the local government strategy for reporting and communication (following the key findings from this thesis).

5.2.1.3 The Role of Boundary or Other Objects in the Sustainability Field

This thesis discussed the presence of 'zero waste' as a boundary object in an active city waste management system in Chapter Four. While existing studies have explored the role of boundary objects within 1) collaboration and 2) in establishing dialogue or translation of meaning between diverse stakeholder groups (Akkerman and Bakker, 2011; Benn and Martin, 2010; Nicolini et al., 2012; Star, 2010; Star and Griesemer, 1989), there is little known about the role of boundary objects in the field of city waste management systems. A notable exception is the work of Rosenlund (2017), who explores the role of epistemic objects in the context of a circular economy program addressing regional waste. That study, however, is specific to epistemic objects rather than boundary objects and does not explore a city waste reduction target. This thesis is the first instance where boundary object theory has been applied to a city waste management system undergoing a waste reduction target. Future research could therefore continue this work through: 1) the exploration of zero waste as a boundary object in other waste management systems; 2) the exploration of other language-based boundary objects in waste management systems (e.g. circular economy); 3) the active production and introduction of language as a boundary object in the sustainability field (i.e. buzzwords or similarly contagious terminology); 4) the exploration of other object types in the sustainability field (e.g. epistemic, activity or technical objects).

5.3 Thesis Outputs

5.3.1 Thesis Distribution to Stakeholders

This thesis was motivated to support change in the context of city waste reduction targets. This intended impact was sought on three levels: 1) local (i.e., the City of Sydney and its 2030

zero waste target); 2) domestic (i.e., Australian waste management, including government policy and public reporting); and 3) international (i.e., other city waste reduction targets).

To promote the impact of this work across these three levels, the thesis (or its findings) will distributed in the following ways after its formal confirmation. Firstly, by being made publicly available (housed digitally) by the UTS Library (aligning with university procedures), where any member of the public can view and download a pdf of the thesis. Secondly, a pdf copy of the thesis will be digitally shared with each participant from the research, as communicated during data collection. This will allow any individual interested in this topic to locate and access the findings from this thesis. Being key stakeholders in the city case study's waste management system, access to the findings of this thesis can equip individuals to make informed change towards the waste reduction target in place. Finally, I intend to distil key findings from this thesis into graphics, short videos and blog posts for clear, accessible and quick transference of knowledge across social media platforms as well as any other spaces that become available (e.g. conferences, blogs, websites, or podcasts that discuss policy, waste or systems content). This may also include the publication of findings from the thesis in peer reviewed journals for greater exposure and accessibility.

5.3.2 Navigation Principles for Understanding City Waste Management Systems and Waste Reduction Targets

In the push for sustainable change in waste management systems, focus can be disproportionately placed on targets. Waste reduction targets that are too frequently: 1) poorly constructed; 2) poorly communicated; and 3) poorly positioned to acknowledge factors that impact change outside of weight-based waste metrics. Systematic navigation of the waste management systems that surround waste reduction targets must be prioritised to refocus how waste is understood. In doing so, change occurring in the system (as well as future required

change) can be taken into consideration to improve the level of impact a waste reduction target can have. The conceptual model developed in this thesis is a navigational device that facilitates the required journey to understanding. Developed through this thesis were insights that can support the navigation of other city waste management systems to inform more effective waste reaction targets.

A series of seven navigation principles were developed as a tool from the conceptual model to prompt users to evaluate other waste management systems and waste reduction targets, see Table 5.1. The first four of these principles were designed to facilitate users to navigate the waste management system to understand the context that shapes the waste reduction target under review. An additional three principles were designed to facilitate users to navigate the scope and application of the waste reduction target over time. The framing of these navigation principles was inspired by the design principles proposed by Pham et al. (2020) for environmental performance measurement. Unlike design principles, these navigation principles support exploration rather than measurement to equip users to refocus the way in which waste management systems are understood. By facilitating a more holistic understanding of waste management systems that acknowledge factors that impact change outside of weight-based waste metrics, users will be positioned to strengthen the rigor of future waste reduction targets.

This section will introduce the seven navigation principles with a brief description of how they can be implemented by users. The discussion of each navigation principle will include a reflective vignette on the City of Sydney case study to demonstrate how the prompts might be implemented.

Table 5.1. Navigation principles for understanding waste management systems and waste reduction targets

Category	Navigation Principles
Waste Management System Prompts	Navigation Principle 1: Existing Sustainability Commitments
	Navigation Principle 2: Material Flows
	Navigation Principle 3: Stakeholder Relationships
	Navigation Principle 4: Gaps in Public Reporting
Waste Reduction Target Prompts	Navigation Principle 5: Detailed Target Definition and Action Plan
	Navigation Principle 6: Baseline Waste Data and Progress Reporting Timeline
	Navigation Principle 7: Detailed Target Budget

5.3.2.1 Navigation Principle 1: Existing Sustainability Commitments

This navigation principle prompts the user to develop a list of existing global, national, state, or local legislation, and targets that impact the waste management system under review (e.g., the UN Sustainability Goals or a national environmental act). This might also include a brief discussion on the anticipated impact of the existing political context on the waste management system and its waste reduction target.

Reflecting upon the City of Sydney case study in reference to the first navigation principle, several pieces of legislation and targets on global, national, state, or local levels were publicly reported to provide a political context that might impact the city waste reduction target, see Section 3.1.2.2. The potential impact of the identified legislation and targets on the city waste management system was not discussed. It would have also been good to see this information

compiled into a summarised discussion in one document to provide a detailed yet succinct political context explicitly relating to the city waste reduction target.

5.3.2.2 Navigation Principle 2: Material Flows

This navigation principle prompts the user to develop a geographic map that illustrates waste movement through the city, including both consumables entering and waste exiting the geographic city boundaries (e.g., consumables such as packaging for building supplies entering and exiting the city waste management system). The map may include waste streams that have unknown quantities. It should also include waste at different stages in the system, such as 1) generation; 2) collection; 3) processing; and 4) final location.

Reflecting upon the City of Sydney case study in reference to the second navigation principle, the physical city boundary was geographically represented across multiple documents. It would have been helpful to see the location of waste movement through the city monitored and publicly reported to better understand the flow of solid waste through the system.

5.3.2.3 Navigation Principle 3: Stakeholder Relationships

Develop a list of key stakeholders that impact the waste management system under review (e.g., landfill organisations or community groups). Consider how each stakeholder will be engaged in relation to the waste reduction target and their level of involvement. This list could be copied onto the geographic map of material flows from Navigation Principle 2. Engagement with the identified stakeholders regarding the waste reduction target could also be considered, including: 1) events; 2) workshops; 3) focus groups; 4) interviews; or 5) surveys.

Reflecting upon the City of Sydney case study in reference to the third navigation principle, the relevance of some stakeholders in the waste management system was identified by the city, such as: 1) not-for-profit organisations; 2) environmental programs; and 3) internal city departments (City of Sydney, 2017c, 2017b, 2018, 2014–15), see Section 3.2.1.3. Connections

between the identified stakeholders and specific material flows were somewhat communicated in overarching categories such as 'industrial and commercial', however these labels were vague and did not list specific stakeholders within these categories. No evidence was observed in the reviewed documents to indicate active engagement with those directly impacted by the waste reduction target. It would be helpful to see the city actively plan engagement with those listed as stakeholders under the waste reduction target explanations.

5.3.2.4 Navigation Principle 4: Gaps in Public Reporting

Develop a list of observed gaps in public reporting from the city local government and relevant waste management stakeholders (e.g., incorrect and absent waste data or assumed knowledge). These gaps may have been observed when completing the other navigation principles iteratively. An additional step that can be taken in addressing this principle can include considering how the gap might be addressed within the waste reduction target that will be reviewed over principles five, six and seven.

Reflecting upon the City of Sydney case study in reference to the fourth navigation principle, no active acknowledgment of any gaps or assumptions was observed in public reporting. It would have been good to see the City of Sydney, or other stakeholders, reflect upon gaps in reporting that can be addressed to improve transparency, inclusiveness, and auditability; following the three qualitative attributes proposed by Lamberton (2005) for sustainability accounting.[37]

5.3.2.3 Navigation Principle 5: Detailed Target Definition and Action Plan

[37] The three qualitative attributes proposed by Lamberton (2005) for sustainability accounting are informed by the financial accounting tradition. 'Transparency' includes processes, procedures, and assumptions. 'Inclusiveness' includes systematic organisational engagement with stakeholders. 'Auditability' includes data and information that is reported, compiled, analysed and disclosed so that reliability can be evaluated.

Develop a detailed and explained definition of the waste reduction target that is publicly reported. Boundaries for the target should be outlined in the definition, including: 1) geographic, 2) political and 3) time boundaries. A rigorous action plan for implementing and measuring the waste reduction target should also be included.

Reflecting upon the City of Sydney case study in reference to the fifth navigation principle, a limited definition and explanation of the waste reduction target was publicly reported; where the zero waste by 2030 target was defined as 90% diversion from landfill, see Section 3.2.1.1. It would have been helpful to include further detail about what the City of Sydney defines as 'waste' to be included in the target, and how they measure diversion from landfill to achieve the target. Regarding boundaries, the City of Sydney has implied physical and political boundaries as limited by their local government area jurisdiction and has applied a definitive time boundary of the year 2030 for their target. It would have been good to see further information about the geographic boundaries of responsibility (i.e., where waste might enter or leave the city geographic boundaries during waste management). The City of Sydney publicly reported brief aims of the waste reduction target and some associated programs, such as organics waste and partnering with not-for-profits in environmental programs. It would have been beneficial to see the city outline an action plan with clear steps and milestones that the city will undertake toward the target.

5.3.2.6 Navigation Principle 6: Baseline Waste Data and Progress Reporting Timeline

Collate a baseline of waste data that spans all waste streams included in the waste reduction target. This should include a timeline for continued measurement against the waste reduction target that will be publicly reported to demonstrate progress. Three primary waste streams of data should be recorded, including, but not limited to: 1) municipal (including households); 2) commercial and industrial; and 3) construction and demolition.

Public reporting of contracted waste management stakeholders should also include: 1) the stakeholder's name; 2) their role in waste management; and 3) the length of their contract.

Reflecting upon the City of Sydney case study in reference to the sixth navigation principle, assorted waste metrics (tonnes, kilograms, percentages of unspecified source figures, number of units) publicly reported in the reviewed texts from the year 2015 and estimations up until the year 2030, see Section 3.2.1.2. The assortment of reporting metrics provides a barrier to comparing waste figures across streams and years. While the city included figures across the three primary waste streams, these streams were not consistently represented across all reporting years. It would have been great to see the City of Sydney report waste data using a valid and agreed upon measurement method that could be consistently tracked annually. The city also included other waste streams such as 'illegal dumping', 'e-waste', and 'New Year's Eve street waste'; however, it was unclear if smaller waste streams such as these fit within previously reported waste data from the three primary waste streams, or were additional figures that contribute to total annual city waste. It would have been great to see the City of Sydney report waste data using a valid and agreed upon measurement method that could then be consistently tracked annually. It would have been helpful to observe the city report from consistent waste streams annually and acknowledge the contextual setting for any smaller waste sources discussed. While the City of Sydney discussed a waste measurement type (diversion from landfill), a valid measurement method that would be employed by the city throughout the waste reduction target period was not observed in public reporting, see Section 3.2.1.1. It would be great to see the City of Sydney develop a valid measurement method (or if existing internally, to be publicly communicated) along with regular public updates of key progress milestones towards the target. While the City of Sydney listed many stakeholders in the reviewed texts (primarily not-for-profit organisations, environmental programs, and internal city), there was no observation of any disclosed stakeholder relationships with organisations contracted by the city for waste management purposes, see Section 3.2.1.3. As a result, there was no observation of any further

information about the contracted stakeholder roles in city waste management or the length of their contracts. It would have been helpful if the City of Sydney had publicly disclosed the names, roles, and contract lengths of organisations directly managing city waste.

5.3.2.7 Navigation Principle 7: Detailed Target Budget

Develop a detailed and explained budget to meet the changing needs of the waste management system over time as it evolves toward the waste reduction target. This should be publicly reported at appropriate intervals. The level of transparency for this public reporting of the plan and associated budget may vary between cities based on contextual governing policy.

Reflecting upon the City of Sydney case study in reference to the seventh navigation principle, 'waste disposal charges' were publicly reported under expenses, then 'cleaning and waste' was publicly reported in the operating budget (City of Sydney, 2019b; City of Sydney, 2020), see Section 3.2.1.2. It would have been good to see the city break down how the waste management funding is being spent (i.e., specific projects, major works or contracts) and how this spending contributes towards the set waste reduction target.

Appendices

Appendix A: Research Question Iterations

Table A.1. Research question iterations throughout the thesis

Meta-Research Question	**Research Sub-Questions/Objectives**	**Time of Recording**
What barriers and enablers exist within communication when individuals collaborate on policy making regarding waste management?	What communication exist (are present)?	November 2018
	What examples [of] success and failure exist?	
	Which specific location (of study/question)?	
How can cities move from current state to zero waste?	Given the system state, what are the challenges of achieving a zero waste city?	June 2019
How can we achieve sustainable city waste management for the future?	N/A	September 2019
What role do objects have in movement towards sustainable city waste management in the City of Sydney area and what factors influence this connection?	N/A	June 2020
How can cities be more sustainable in waste management? How can the City of Sydney ecosystem be more sustainable in waste management using a zero waste goal?	What barriers and enablers exist in the City of Sydney ecosystem to achieving zero waste as a goal for sustainable waste management?	September 2020
	What are the role of themes and objects in communication within the City of Sydney ecosystem striving to achieve zero waste as a goal for sustainable waste management?	
	What are the role of themes and objects in communication within the City of Sydney ecosystem striving to achieve zero waste as a goal for sustainable waste management?	
How can ecosystems of people shift towards more	What does a city waste management system in a period of transition look like and how can this be represented graphically?	September-October 2020

sustainable practices, supporting future life? What factors contribute to City ecosystems achieving zero waste? What is the role of factors and objects for transitioning city ecosystems to achieve waste reduction goals?	What is the role of factors, such as barrier or enablers, in achieving a time-based sustainability goal?	
	What is the role of objects in collaboration towards achieving a sustainability goal?	
What is the role that drivers of change and boundary objects have in transitioning city ecosystems to achieve waste reduction?	What are the characteristics of a city waste management system (WMS) and how can this be represented graphically?	January 2021
	What drivers of change (such as barriers and enablers) to achieving waste reduction exist in transitioning cities, and why?	
	What role could boundary objects play in collaboration towards city waste reduction, and why?	
What is the role of barriers and boundary objects in a transitioning city waste management system achieving a sustainability target?	N/A	January 2021
How can change in city waste management systems towards waste reduction targets be improved?	What are the key design principles for mapping and measuring a city waste management system transitioning towards a waste reduction target?	July 2022
	How do contextual factors and key events impact a city waste management system, and therefore its ability to achieve a waste reduction target?	
	How can objects help us observe and understand challenges in an existing city waste reduction target? How can objects help us observe and understand challenges experienced during a waste reduction target in a city waste management system?	
How can change in city waste management systems towards waste reduction targets be improved?	To explore and describe an active city waste management system attempting a waste reduction target.	July 2022
	To explore and describe contextual factors and key events that may impact an active city waste management system attempting a waste reduction target.	

	To explore and describe language in a waste reduction target that acts an object in an active city waste management system.	
What does system change in city waste management look like when undergoing a waste reduction target?	To explore and describe an active city waste management system undergoing a waste reduction target	December 2022
	To explore and describe key factors that may impact an active city waste management system undergoing a waste reduction target	

Appendix B: Graphic Mapping of the Case Study Waste Management System

Table A.2. Graphic mapping of the case study waste management system iterations throughout the thesis

Map or Graphic Type	**Iteration Number**	**Number of Nodes or Headings**	**Description of features included in the map**
Australian Waste Concepts Linking	*Iteration 1*	20	A hand-drawn graphic showing the relationship between key themes, stakeholders and locations across waste management in Australia. Visually appears as a list of headings with relational arrows between them on the right-hand side.
	Iteration 2	28	A hand-drawn graphic showing the hierarchical relationship between key themes, stakeholders and locations across waste management in Australia. Visually appears as similar to a family tree, where headings descend downwards with relational arrows running in a downwards direction between them.
	Iteration 3	22	A digitally generated graphic showing the relationship between key themes, stakeholders and locations across waste management in Australia. Visually appears as similar to an ecosystem map, with headings in three main groups ('Change', 'Projections', and 'Consequences') with relational arrows between them.
Sydney Waste Ecosystem	*Iteration 1*	30	A hand-drawn graphic showing the relationship between key themes, stakeholders and locations across waste management in the case study area. Visually appears as an ecosystem map, with a combination of written and illustrated headings with relational arrows between them.

	Iteration 2	19	A hand-drawn graphic showing the relationship between key themes, stakeholders and locations across waste management in the case study area. Visually appears as an ecosystem map, with a combination of written and illustrated headings with relational arrows between them.
Sydney Waste Stakeholders	*Iteration 1*	5	A hand-drawn graphic showing the relationship between key stakeholder groups across waste management in the case study area. Visually appears as a Euler diagram, with headings in five main groups ('Households & Individuals', 'Federal Government', 'State & Local Government', 'Industries & Businesses', 'Communities') overlapping in different ratios.
	Iteration 2	135	A hand-drawn graphic showing the relationship between key stakeholders within 6 main stakeholder groups across waste management in the case study area. Visually appears as a Euler diagram, with headings in six main groups ('Households & Individuals', 'Federal Government', 'State Government', 'Local Government', 'Industries & Businesses', 'Communities') overlapping in different ratios.
	Iteration 3	575	A digitally generated set of tables showing the relationship between key stakeholders across waste management in the case study area. Visually appears as an Excel document with an index page, a key page and 9 tables showing a cross-section of relationships strength between key stakeholders following six main headings ('Households & Individuals', 'Federal Government', 'State Government', 'Local Government', 'Industries & Businesses', 'Communities').
	Iteration 4	375	A digitally generated set of tables showing the relationship between key stakeholders across waste management in the case study area. Visually appears as an Excel document with an index page, a key page, a table summary page and 15 tables showing a across section of relationships strength between key stakeholders following all combinations of six main headings ('Households & Individuals', 'Federal Government', 'State Government', 'Local Government', 'Industries & Businesses', 'Communities').
	Iteration 5	34	A digitally hand-drawn graphic showing the relationship between key themes and stakeholders across waste management in the case study area.

			Visually appears as an ecosystem map, with a combination of written and illustrated headings with relational arrows between them.
	Iteration 6	31	A digitally hand-drawn graphic showing the relationship between key themes and stakeholders across waste management in the case study area. Visually appears as an ecosystem map, with a combination of written and illustrated headings with relational arrows between them and a key identifying 'trouble makers'.
Projected Inflation of Waste Disposal Charges for the City of Sydney 2019-2029	*Iteration 1*	N/A	A digitally generated line graph comparing the projected waste disposal charges to 2028-29 from the City of Sydney against the calculated inflation of the 2019-20 waste disposal charges to identify the high anticipated future disposal charges for an organisation aiming to reach zero waste (that they have defined at 90% avoidance from landfill). Visually appears as a line graph with two lines increasing over time where the 28-29 waste disposal charges anticipated by the City of Sydney are $28.8 million, whereas 1% inflation of the 2019-21 waste disposal charges is $24.2 million.

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