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Critiquing commodification in environmental governance
examples of urban waste governance in Cape Town, Rotterdam, and Bristol

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Critiquing commodification in environmental governance: examples of urban waste governance in Cape Town, Rotterdam, and Bristol

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Critiquing commodification in environmental governance: examples of urban waste governance in Cape Town, Rotterdam, and Bristol

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Glossary

Term	Definition
Abductive reasoning	Inference primarily involving the formulation of probable explanations for a set of observations that are assumed to be incomplete.
Circular Economy	A development in market economics which assigns value to purposeful re-use and recycling of waste materials rather than disposal and replacement.
City	The area within an administrative boundary of a metropolis – including phenomena which identify as being part of it or operate in connection with others that are within it.
Commodification	The incorporation of phenomena into market economies by attributing monetary value to such phenomena. This entails the relative exclusion of alternate notions of value or significance such as social or environmental.
Critical realism	A philosophy which holds that behaviour is neither determined solely or predominantly by the structure of social and material circumstances or forces, nor by the agency of individual freedom of choice. Institutional or individual thinking, being and action are instead affected by the complex, indeterminate interplay of these factors (Giddens, 1984; Whaley, 2018).
Critique	The amorphous act of challenging or contesting dominant ideas or norms.
Discourse	The exchange of ideas imbued with scientific or pragmatic authority in specific social-material contexts. This may involve non-human actors, but usually involves powerful individuals or organisations (Van Dijk, 1997).
Domination & Emancipation	The establishment and maintenance of uniformity in thinking, rules or policies, and concomitant activities (such as the governance of waste in cities in this case). And emancipation is in turn understood as the *effective* disclosure and contestation of any form of domination (Boltanksi, 2011).
Food-Energy-Water Nexus	A concept highlighting the interdependence of water, food, and energy systems to optimise inter-sectoral resource usage (Scanlon et al., 2017).
Governance systems & processes	"*Self-organising, inter-organisational networks*" that are goal-oriented to "*authoritatively allocating resources and exercising control and co-ordination*" (Rhodes, 1997, p. 653). Governance processes also involve assignments of responsibility and oversight functions for accountability.
Ideational power	A concept that describes the role of actors in shaping the way in which norms are established, maintained, or critiqued/contested ideationally.
Institution and institutionalisation	An organised entity which is emblematic of a particular form of normative thinking, being, or acting – potentially comprising multiple dimensions of being or identity, including semantic or linguistic, material or physical, and normative or regulatory (Boltanski, 2011, p. 79). Institutionalisation involves the entrenchment of authoritative regulation or policy as well as the popularisation of linguistic and behavioural conventions or norms.

Interdisciplinary	"[Academic] *disciplines … are … also social structures, organisations made up of human beings with vested interests based on time investments, acquired reputations, and established social networks that shape and bias their views on the relative importance of their knowledge. As social organisations, disciplines participate in and contribute to conflicts over political, economic, legal, and ethical decisions, over the distribution of resources and life chances.*" (Stehr & Weingart, 2000, p. xi). *Inter*disciplinary research, in this context, therefore, attempts to transcend and alter the social structures of disciplines by interrelating their theories.
Outcomes	As opposed to principles, intentions, processes, or outputs (direct results of an activity irrespective of effects or the achievement of goals), outcomes are consequences or impacts that can be contextually associated with any given activity (Von Assche et al., 2014, Partelow et al., 2020).
Positivism	An epistemological branch in philosophy of science which holds that the truest claims to knowledge are attainable by means of the scientific method and its empirical foundations (Gunnel, 1981; Pilon, 2021).
Retroductive reasoning	The process of "*seeking to establish through forms of argumentation what is basically characteristic and constitutive of the structures and mechanisms*" underlying a phenomenon or a set of phenomena that is/are of analytical interest in a particular context (Tikly, 2015, p. 247).
Stochastic	An attribute indicating that the phenomenon in question is not precisely predictable. This is specifically associated with interplays of agentive and structural counterforces of institutional continuity and discontinuity, and with non-linearity in general (Pierson, 2000; Greif & Laitin, 2004).
Systems thinking	Analytical approach which emphasises the interconnections underpinning systemic phenomena, like sustainability crises, implying an analytical imperative to identify differing individual components, their connections, and the dynamics/impacts thereof in order to fully understand any systemic phenomenon in question (Barile et al., 2018; "Imagine a world without hunger, then make it happen with systems thinking", 2020).
Transdisciplinary	Purposeful inclusion of non-academic approaches or ideas (often relevant to policy which applies to heterogeneous or complex groups and objects of analysis) in the process of academic knowledge production (Maasen & Lieven, 2006; Dedeurwaerdere, 2013; Koskinen & Mäki, 2016).
Triangulation	The combination of methods and their outputs in social science, often due to uncertainty around veracity or suspected insufficiency of interview data saturation, in order to produce multifaceted views on the subject matter in question (Webb et al., 1966; Davies, 2001; Lorenzoni & Benson, 2014).
Urban	Adjective indicating that the relevant noun is related to or in a city.

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Abstract

Is the governance of waste in cities being encroached by logics of commodification? This question is posed to analyse a capitalistic turn in environmental governance. Encroachment of such logics is hypothesised to occur by innovation- and discourse-based means. But, alongside changes in how urban waste governance systems are contested, there are changes in how they are maintained and reinforced, *e.g.*, through information technologies. Therefore, this thesis **aims** to better understand the commodification of waste – including relevant ideas with political traction – which is shaping and shaped by institutionalisation in urban waste governance. Three **objectives** follow this aim. The first is to identify and critically analyse institutions sharing explicit alignment with either or both circular economy or food-energy-water nexus ideas, and relationships between these institutions in Rotterdam, Cape Town, and Bristol. The second is to investigate and critically analyse the role of ideational power in processes of institutionalisation, or institutional change, within urban waste governance systems. And third, to synthesise and simulate factors affecting the outcomes of institutionalisation or institutional change aligned with circular economy or food-energy-water nexus discourse in different urban waste governance systems. An innovative mixed method **methodology** which includes social network analysis, qualitative analysis, and agent-based modelling has been developed and applied to achieve these research objectives. Methods were selected and integrated with reference to an interdisciplinary theoretical framework including environmental governance and critical institutionalism, a systems-thinking analytical framing, and a conceptual frame that foregrounds context in the interaction between research and government policy. **Results** suggest that the way critique is mobilised and affects institutional networks through which waste governance occurs in cities is becoming increasingly complex and nuanced. Whilst this may mean that contestation is increasingly open to influence or disruption, caution is warranted in such interpretations. A shallow process of institutional diversification may obscure deeper rigidity of established power hierarchies in urban environmental governance. How such systemic asymmetries or inequities might be addressed by innovative forms of critique is an open question, but a systems-thinking analytical approach which is sensitive to contextual factors determining how and whether critical engagement affects policy, and its outcomes, is instructive. The commodification of waste and of competing ideas interacting with waste governance systems calls for holistic analysis of urban waste governance networks. Mixed methods that appraise and integrate computer based- and empirical forms of social data enable holistic-critical analysis of the governance networks wherein hegemony or domination is difficult to pinpoint and destabilise. Such exercises of holistically analysing and critically engaging with diffuse / fluid domination in urban waste governance networks give impetus to unorthodox alternatives to commodification – both in terms of governance processes and outcomes that we might reasonably expect from those.

1 Introduction

1.1 Preamble

The production of waste has always been an inevitable and developing feature of being human. Our bodies need food, air, and water. In combination, metabolising these essentials gives us the energy to prosper as individuals, groups, and as a society. However, as our ways of life evolve – differently between different groups in different places – our interactions with the environment transform. Especially over the past century, our levels of resource extraction and use have intensified significantly. Thanks to this, scattered tribes gradually integrated and culminated in global society as we know it. Now, our cumulative metabolism far outweighs the sum of our individual bodily needs. The industrial revolution made this doubly so. This revolution, or at least its early stages, is mainly characterised by the replacement of human labour with mechanised labour or machines, and the migration and concentration of large swaths of people to increasingly urbanised settlements where mass-production and -consumption became institutionalised. These settlements were disorganised, dirty, overcrowded, and hazardous to humans and other life forms.

This has changed in many places, but a global average of 23% of city-dwellers still live in slums, or areas characterised by unsanitary environments with insufficient amenities and -infrastructure. The figure is highest in Asia (31%) and Sub-Saharan Africa (56%), where the bulk of our global population resides and grows. Most of us now live in cities and this trend is expected to intensify. Cities are the bustling hubs of our institutionalised mass-productive and -consumptive ways of life. Hence, waste is abundant in cities. The mass of all man-made substances surpassed that of all biomasses on Earth in 2020 (Elhacham et al., 2020). But more than just centres of industrial activity and the flows of raw materials and man-made by-products that result from linear economies, cities are hubs of the latest, ongoing stage of the industrial revolution. Information and the technologies mediating its transmission permeate every aspect of our daily lives. Now, we must learn from bygone stages of the industrial revolution which saw benefits and costs distributed unevenly. Technical innovations that conform to the root causes of linked social and environmental crises can reproduce inequalities that straddle social and environmental categories. This “digital” industrial revolution, with its flows of valuable information and data increasingly swaying the way we all behave, must therefore be analysed through a critical sociological lens.

I would like to start by positing that the focus of such an analysis should be on behavioural drivers. The great mechanical, and now digital, revolution is not only a random result of passive individual and collective behaviour. These institutionalised and institutionalising changes that so profoundly influence the way we live our everyday lives are arguably also the outcomes of purposeful individual and commercial behaviours. One area that illustrates this clearly is, as indicated above,

the production and governance or management of urban wastes. Here, two recent innovations illustrate how waste relates to socio-environmental crisis. First, the extraction and intensive mass-combustion of fossil fuels is fuelling climate change – to the disproportionate and palpable detriment of the poor. Second, the invention and intensive mass-production of information and communication technologies is fuelling destructive mining activities in impoverished places to produce goods and services that mostly benefit people in wealthy places. More broadly, technical innovations are transforming the way many of us heat our homes, move around, and share ideas. And, most importantly for the scope of this research, technical innovations energise and animate profound transformations in our cities and concomitant usages of water and food. But also, and crucially, these changes also make some individuals and groups rich whilst leaving others behind.

If we think of waste as a "by-product", we may see it as something incidental or inadvertent. However, in this study, waste is construed not only as the unavoidable outcome of technological and natural processes but as an outcome of well-informed governance processes; as something that someone, or a group of individuals, ought to take responsibility for. This notion of waste is driven by a commitment to the principle of accountability. Waste is intertwined with disparities of wealth and power. In richer settings, waste collection or recycling and its enriching effects are common. For example, the absence of waste on streets, in waterways, and in the air provides public health benefits whilst waste removal and sorting offer opportunities for profit to be made from recycling. In poorer settings, waste accumulation and its toxic effects are common. Such effects, for example, range from the spread of preventable diseases to social conflict due to limited living space being further constricted by environmental pressures (Johnston et al., forthcoming).

The cleanliness – the presence or absence of waste – of a street, neighbourhood, or city reflects its socioeconomic status. The institutionalisation of waste as a feature of contemporary urban society is such that its rate of flow is not treated as a socially relevant question; instead, how waste is *dealt with* imparts insights into the split between social scenes of prosperity and squalor. How waste is dealt with depends on governance processes which hinge on money, politics, and policy. I assert a social notion of waste despite – and perhaps precisely because of – my belief that governance processes are difficult to keep track of and trace in our complex urban societies. This challenge is compounded by the ever-expanding and ever-developing array of industrial supply chains, and the break-neck speed of information and communication technology's development.

1.2 Problem

Underpinning these rapid expansions and developments in information and communication technologies and industrial supply chains (and waste) is a social system which incentivises and fuels the commodification of an ever-wider range of things: capitalism. Capitalism's logic of

commodification not only drives an unrelenting forward march of mechanised supply chains (plus wasteful practices of take-make-dispose these historically entailed) and an even faster progress in information and communication technology; it also increasingly takes waste directly into its fold.

Of course, waste commodification is not necessarily a new phenomenon – since humans always aimed to reutilise scarce resources. Nor is waste commodification a problem per se. It is preferable that existing streams of waste are valued enough to be repurposed for productive use, as opposed to them being thrown away (burnt, dumped, buried, etc.) to minimise financial, environmental, or reputational costs. However, in recent forms of capitalist societies, "throw-away" culture has been the status quo for some time; with social and environmental consequences largely ignored at our peril. This is the linear economy model. But the commodification of waste *is* a problem if the imperative of halting and counteracting mass-production and -consumption for its own sake (a hallmark of contemporary capitalism and a major cause of global problems like biodiversity loss and climate change) is set aside because the repurposing of existing waste streams becomes institutionalised for financial or political reasons. Thus, focus on environmental care gets lost or used to placate critiques of the growth-focused (or capitalist) status quo. The scale of potentially gainful waste streams is greatest in cities – where mass-production and consumption are most concentrated. Therefore, such problematic waste commodification is anticipated to occur in cities. For clarity, problematic waste commodification refers to the incorporation of waste into market economies through the attribution of monetary value to waste. This, I postulate, entails the relative silencing of alternate ways of evaluating waste and its causes in social and environmental terms.

Not unrelated then, the most tangible and stark examples of lived inequality can be observed in cities. Waste – and the inconsistent way it is handled or dealt with – has long been emblematic of this inequality. This is not a ground-breaking observation. It is, to the contrary, something we might label as "common sense". To my mind, the commonplace status of inequalities symbolised by the skewed distribution of residual waste in our cities begs serious questions about governance, or the lack thereof. How can it be that this global trend continues: where poorer urban districts are being consistently and disproportionately exposed to toxic residues and resulting impacts of the excess in mass-production and consumption practices which enrich an already privileged few?

The answer may emanate from a closer look at ideas that are widely seen – and in some cases implemented – as solutions to the waste problem. Important contrasts have been made with the linear economy model through some of these ideas. Examples mainly involve the integration or transformation of existing supply chains to optimise material efficiencies and minimise socio-environmental consequences that are increasingly open to scrutiny and regulatory strictures. Most notable are the *circular economy* and the *food-energy-water nexus* concepts. At face value, these

are constructive ideas, even if only by virtue of their being alternatives to our historically linear economies separated from each other in sector-silos (thus precluding waste-reducing *integration*).

But the root causes of institutionalised mass-productive and -consumptive excesses, which have had adverse social and environmental impacts, are not necessarily addressed in cases where these ideas are incorporated into complex urban waste governance systems. Equally, theoretical conceptualisations and real-world implementations of both the CE and FEW nexus rarely appear to consider the implications of such innovations for equality and social justice. The possibility that root causes of wastefulness, environmental degradation, inequity, and disempowerment are *not addressed* in implementations of circular economy and food-energy-water nexus style urban waste governance systems is perhaps outweighed by the possibility that such socio-environmental outcomes may be thus *reinforced*. This latter, more dangerous possibility relates to the nature of the industrial revolution described above. As a prerequisite to physical or technical innovations, there is novel human thought. This is perhaps an obvious statement, but it is crucial to make the ideational preconditions for physical or material innovations explicit so that those preconditions can be critically assessed. The transformative thinking of individuals and groups who pioneer our mechanical and digital inventions could be amplified by those self-same inventions – rippling out into an ever-more dynamic, unequal, and connected society. Furthermore, it is no longer only us human beings who are more dynamic and connected. Ideas and machines are themselves also increasingly mobile and integrated; able to influence human thought and the material world. This is important when we ask why waste governance fails to improve socio-environmental outcomes.

It seems counterintuitive, in the context of historical limits to the informational resources at the average person's disposal, that a profound abundance and integration of ideas could *constrain* our ability to effectively challenge or contest the root causes of waste in all its forms. But, in this thesis, I postulate that this is indeed the case and analyse the operation of the circular economy and food-energy-water nexus concepts as they are institutionalised in urban waste governance systems with an emphasis on the importance of critique. Critique is the means by which dominant ideas are contested and challenged: an act that can take many shapes and can have fundamental or superficial effects. My construal of problematic waste commodification – which effectively sets aside the imperative of counteracting or reversing mass-production and -consumption for its own sake – is intertwined with critique. The ongoing (and perhaps permanent) revolution which brought about great increases in the amount and varieties of waste we must deal with and govern in cities (as well as the amount and variety of ideas which might influence how we go about doing that) stem from changes in human thought. It is important to recognise how and why this happens. Mechanisation, urbanisation, and digitisation are enabling abundant ways of life for some, but at

the same time, these innovations can cause squalid ways of life for others. These lived realities can (and often do) give impetus to ideational movements that can make or break the status quo.

By recognising why the current state of affairs may be actively prolonged and extended, and by identifying the potential motivating factors for active contestation and resistance to the same status quo, it becomes possible to understand how commodification interacts with urban waste governance. To that end, it is necessary to critically analyse examples of solutions that seem to be caught up in the commodification of waste; especially examples of solutions which have the political traction to affect processes and outcomes of institutionalisation in existing urban waste governance systems.

Critique is important in this because, in a context of abundant information and communication technologies permeating our daily lives, popularity and political traction may well be indicative of, or conducive to, the longevity of a dysfunctional status quo. Importantly, the power to imbue an idea with political traction is not only afforded by money and knowledge, but also by relationships. It is not only what you have and what you know that can give you such power; it is also who you know. Given the influence of relationships, which tend to be shaped by mutually beneficial financial flows and/or their alignment with popular ideas which influence policy regimes (such as urban waste governance), it is crucially important that such relationships are critiqued. Failing this, such relationships can become springboards for further institutionalisation of a social system propelling commodification at our social and environmental peril: capitalism.

1.3 Aim & Objectives

Waste as an expression and consequence of the root causes of multidimensional inequalities – which straddle social and environmental categories in our lives – is a theme throughout this thesis, as is the advent of information and communication technologies. In combination, these layers of context anchor my critical analysis of waste through a sociological lens. Thus, I aim to better understand the commodification of waste – including ideas with political traction – which is shaping and shaped by institutionalised urban waste governance. The selected ideas in this case are the circular economy and food-energy-water nexus. For comparative purposes, I will critically analyse the operation of these ideas through three case studies covering different cities. I justify this research design in Chapter 2.

To achieve that aim, within my case study sites, I first identify and critically analyse institutions sharing explicit alignment with either or both circular economy or food-energy-water nexus ideas, and relationships between these institutions. I do this by systematically analysing data obtained from websites indicating alignment with these ideas – and relations between aligned institutions.

Second, I investigate and critically analyse the role of ideational power in processes of institutionalisation, or institutional change, within urban waste governance systems. I do so by engaging key representatives of institutions identified as aligned with either or both the circular economy or food-energy-water nexus ideas in different urban waste governance systems. This is coupled with critical analysis of financial statements, website content, and secondary data sources.

Third, and lastly, I synthesise and simulate factors affecting the outcomes of institutionalisation or institutional change aligned with circular economy or food-energy-water nexus discourse in different urban waste governance systems. I do this by extrapolating observed attributes of these urban waste governance systems, including structure, composition, and ideational power's role.

1.4 Layout

The remainder of Chapter 1 is structured as follows. First, I present a background to the study which includes introductory practical and theoretical context. Then, I present hypotheses and key research gaps. Next, I provide my positionality statement, followed by the research questions that guide my methodology to achieve my research aim and objectives. This is followed by the thesis scope, which delineates what is and what is not included in this research. And then, as a precursor to a more extensive argument for the theoretical and practical value this study is hoping to add, I introduce the relevance of this research design by arguing its potential contribution to theory and practice. Lastly, I close by briefly signposting the sequence and content of the remaining chapters.

1.5 Background

The first theoretical pillar of this thesis, environmental governance, is conceptualised as follows. Governance – especially in the context of complex, diverse, and dynamic settings like cities – is distinct in that it has moved past historical institutional arrangements that were structured around a singular hub of power. In recent history, these singular hubs were national governments. However, the onset of contemporary capitalism and international governance institutions have moved power away from nation states. Likewise, ongoing urbanisation and empowerment of city-administrations have further detracted from national power. These changes have precipitated in simultaneously more independent and interdependent cities that are increasingly free to design and implement rules and incentives that make local sense. However, this new and progressive autonomy becomes challenging when a wide variety of versatile ideas (that can overtly compete with one another) become easier to entrench using strategic communication and technology. This is challenging because democratic imperatives of reaching consensus are hindered. In particular, the commodification of avenues along which a widening variety of ideas can be mobilised means that those ideas that serve established vested interests might be likeliest to gain political traction.

General governance theory, which leads us to understand governance systems as heterogeneous networks through which resources (*e.g.*, money, expertise, and ideas) are exchanged (Rhodes, 1997; Kooiman, 1999), has developed into the more specific branch of environmental governance. Important contributions from general governance theory still apply to said new branch: inertia should be contested by means of evaluative learning – especially since old questions remain about i) the authenticity of discourse circulating in systems when power brokers control information, and ii) democratic accountability in opaque governance systems (Rhodes, 1997; Kooiman, 1999). In complex, dynamic, and diverse societies characterised by vast spectrums of money, expertise, and ideas exchanged through innovative technologies, issues of authenticity, accountability, and evaluative learning especially beset environmental governance *networks* (Cowell et al., 2020). Therefore, as I elaborate in Section 2.2.1, it is primarily the works of Koch et al. (2021), Beunen & Patterson (2019), and Partelow (2020) which inform the environmental governance aspect of the theoretical framework I apply in this study. Partelow et al. (2020) offer an instructive systematic review of how the theory of environmental governance has historically developed. There is potential for interdisciplinary applications of this literature, emphasising processes and outcomes of change in environmental governance systems (Von Assche et al., 2014; Partelow et al., 2020). Beunen & Patterson (2019) aim to advance environmental governance theory by combining it with institutionalism theory – a pursuit that resonates with my overarching research design. Koch et al. (2021), in an interdisciplinary spirit, apply a combination of social network theory and narrative analysis to understand how environmental governance entities form collaborative networks by means of *narrative congruence*. This is an important theoretical point of departure for my research design, which I elucidate in Chapter 2. However, there are also significant divergences between the approach taken by Koch et al. (2021) and the approach I take here (as is the case with regards to Beunen & Patterson (2019); I explain relevant divergences in that respect in Section 2.2.1). The approach I take here *problematises* "narrative congruence" by investigating how specific (semantic) vehicles of ideational power permeate networks of urban environmental governance entities. Koch et al. (2021) explicitly call for further research which is sensitive to regional context and generates granular understandings of how place-specific social structures and narratives inter-relate with environmental governance entities, and how cumulative outcomes of governance processes achieve global or transnational sustainability goals (or not).

In the context of cross-cutting frontiers of commodification (cutting across the waste and information and communication technology spheres, in this case), the entrenchment of popular ideas warrants critique. This applies to interactions between research and government policy – which is one means by which popular ideas can be institutionalised in any society. In other words, the way research influences government policy can have an impact on how we live and therefore

it is important that those ideas which appear to predominate this interaction are critiqued. Social movements are historically relevant for such institutionalisation; they challenge and contest dominant ideas that are either already policy or have political traction. An important feature of critique, irrespective of whether it comes from activists or academics or elsewhere, is that it should convey emancipatory intent. Emancipatory intent involves the disclosure of existing inequalities of wealth or power and the overt or explicit rejection of institutionalised forms of domination. There is too little awareness of (and research into) the role of ideational power in limiting the potential impact of critique toward emancipatory change within urban waste governance systems.

These imperatives are at the very heart of the second theoretical pillar in this thesis: critical institutionalism. This patently *critical* variety of institutionalism distinguishes itself from (parallel and closely related) other institutionalisms which instead focus on the relevance of discourse in dynamic but persistent asymmetries of power. Critical institutionalism is most appropriate for my research design because it foregrounds the crucial emancipatory potential with which agentive expressions of critique are imbued *and* it recognises institutional inertia. Specifically, I associate problematic institutional inertia with the creeping logic of commodification, which is becoming ever-more pervasive in capitalist society – and specifically in the governance of waste in cities. Hence, I analytically accommodate the role of discourse in dynamic but persistent asymmetries of power, using the (comparative) case of urban waste governance, in this research design. Therefore, the circular economy and food-energy-water nexus ideas are seen as discursive trends in urban waste governance systems which, I postulate, may be suffering from institutional inertia. Part of the discourses I accommodate in this analysis is critique conveying emancipatory intent.

There is a tension between the context in question (increasingly diverse, dynamic, and complex urban waste governance systems in cities) and the monolithic logic of commodification which I problematise. An introductory account of my rationale for selecting circular economy and food-energy-water nexus discourse can help resolve that tension while my full reasoning for selecting these ideas and for construing them as instantiations of discourse is set out thoroughly in Chapter 2. Briefly, circular economy and food-energy-water nexus ideas share the aspiration to transform existing supply chains in order to minimise waste. In this aspiration, both of these ideas are relevant to urban environmental governance policy. However, dominant institutions may exert counterforces to control or constrain the processes and outcomes of any such transformation. Information and communication technologies are ideal tools with which such counterforces can be brought to bear. The complex, diverse, and dynamic nature of cities in general and urban waste governance systems in particular compound the effectiveness of such tools. In a system where a wide variety of agents interact with divergent interests and an unstable social landscape, it is

difficult for an idea to take root. But if an idea gives credence to a frontier of commodification, that idea may be effectively promoted, adopted, and entrenched by dominant institutions despite such difficulty. On the other hand, if an idea diminishes or undermines a frontier of commodification, that idea may be effectively discredited, rejected, and dislodged from popular discourse by the same dominant institutions. This is why the interconnectedness or relationships characterising contemporary urban waste governance systems should be analysed critically: because such relationships and discourses can influence policy outcomes in a significant way. Whether and how circular economy and food-energy-water nexus ideas affect policymaking processes and outcomes is entwined with whether and how institutionalised interests express these ideas discursively. To address this theoretical and empirical complexity, I refer to Figure 1 below.

Figure 1: *A schematic visualisation of the complementary conceptual, theoretical, and analytical frameworks anchoring this research design (Barile et al., 2018; Weyrauch & Echt, 2018).*

To elaborate on Figure 1, Varpio et al. (2020) usefully describe the difference between conceptual and theoretical frameworks. The former framework, they argue, adds value to the relevance and prospective contribution of a research project by bringing a distinct angle to the questions of why the study is important and how it can advance current knowledge (Varpio et al., 2020). The latter (theoretical) framework refers to the logical interconnection of concepts and premises (drawn from one or more theories) and the subject matter of a given research project (Varpio et al., 2020). Varpio et al. (2020) go further to distinguish these frameworks by comparing the research modalities typically applying each in different ways. For example, the "objectivist deductive" approach is contrasted with the "subjectivist inductive" approach – with each typically entailing a unidirectional research process which (in the subjectivist inductive case) either starts with data, then theory, then theoretical framing, and ends with conceptual framing; or the other way around (in the objectivist deductive case). My research approach is a combination of both the subjectivist inductive and the objectivist deductive approaches. For more detail, I elucidate how and why my combination of frameworks in Figure 1 emerged during my research process in Chapters 2 and 3.

1.6 Positionality

I am a South African white male of European ethnicity. I was born in 1993 in the rural Free State province of apartheid South Africa, in the country's judicial capital, Bloemfontein. I grew up nearby in a small town where I stayed until the age of 16. My first language is English, and my second language is Afrikaans. Afrikaans is widely associated with the oppressive "Nasionale Party", which ruled apartheid South Africa. The end of that regime, and the optimism in its wake, defined the social context of my childhood outside the confines of my home; and it was hailed in South Africa and around the world as a pivotal victory for emancipatory social movements. But, I observed that political change does not necessarily deliver economic or broader social change.

For the first time, people of all races participated in a truly democratic South African national election in 1994; and in every election thereafter. However, the glory did not last long among the majority of non-white South Africans, many of whom remained as poor as they were before. Nonetheless, the integration of historically segregated communities began. I remember many conflicts. Nobody expected integration to be simple. The rules of the political game had changed, but social attitudes and the rules of the economic game had not. As a child, one of the only close relationships I had with a non-white person was with an elder Sesotho woman who worked for my parents. She played an enormous role in my life, but it was only because of a capitalist market that commodified her as cheap domestic labour that I had the opportunity to learn about her way of life – which revolved around work – and to develop a close relationship. Hers, like that of many, is a difficult life where healthy food, clean running water, electricity, and clean streets are unattainable luxuries. It is this lived reality of deprivation that contrasted with and enabled my

own way of life as a child: which was privileged and comfortable at the opposite edge of our small town. Alongside our comfort and privilege, there was waste and excess. I find the tension between food-, energy-, and water wastage and excess versus acute poverty and squalidness problematic.

Historical injustices still have not been resolved by the political revolution that culminated in the globally celebrated end of apartheid. This experience still motivates me to investigate interrelated environmental issues and systemic shortcomings of contemporary social structures. My work in the South African domain of policy advocacy gave me the impression that democratic institutions fail to change the lives of many millions of historically and currently deprived people, despite their significant power and resources. And it solidified my impression that in South Africa (and likely elsewhere), political rights have evolved whilst the fundamental logic of capitalism (that drives the commodification of human beings and the environment) has not altered meaningfully.

I started this doctorate in early 2019 through the University of Cape Town. I was motivated by my concern that legal and political disempowerment has been replaced with economic- and broader social disenfranchisement. With this background, at the start of 2020 when the Covid-19 pandemic emerged, I transferred to Coventry University, in England. Physically moving was not an option then. But in February 2021, I moved to Edinburgh, Scotland, where I live at the time of writing. I have encountered sometimes loud and affirmative discourses advancing the logic of commodification, on the one hand, and sometimes silent struggles against intense environmental degradation and disempowerment, on the other. I partly assign such skewed volume to the fact that the techniques with which discourse is mobilised are evolving more rapidly than, and perhaps contradictorily with, critical governance processes through which our social and environmental outcomes can be improved. That is why I intend to advance theory which addresses the interplay of agency, discourse, policy, and structure in institutionalised urban waste governance systems.

1.7 Hypotheses & research gaps

The circular economy and food-energy-water nexus concepts are politically tractable in various national settings, but radical critique of mass-productive and -consumptive behaviours is not. This is even though mass-production and -consumption, with their ties to contemporary capitalism's logic of commodification and growth, are causes of waste and its socio-environmental impacts.

I hypothesise that this divergence of political tractability can be causally related to the notion that urban waste governance systems comprise highly interconnected social structures through which strong institutions wield and mobilise power in ideas – and thus maintain their dominance and the status quo of waste commodification. There are three aspects to my hypothesis, linked to gaps in the literature, which I introduce below and expand on in Chapter 2.

First, prolific information and communication technologies prevent a variety of institutions that are involved in the governance of urban waste to effectively contest the status quo because despite their diversity or heterogeneity, these institutions' shared alignment with circular economy and food-energy-water nexus ideas (which is facilitated and projected through information and communication technologies) precludes radical alterity. Second, the pervasion of urban waste governance systems with logics of commodification enables dominant institutions to use their power to imbue these ideas with authority and, at the same time, to steer their impact on practice and policy away from radical change. Third, the iterative and constant institutionalisation and re-institutionalisation of urban waste governance systems enables unaccountable expansion and stabilisation of dominant interests through diversification and complication of commodification. These sub-hypotheses are related to four gaps in the literature, which I elaborate on in Chapter 2.

The first gap stems from the need for more interdisciplinary theoretical and methodological approaches to solve the interconnected problems of wastefulness, environmental degradation, inequity, and disempowerment. The systemic and interrelated nature of these socio-environmental problems is amplified by our increasingly complex social fabric, which is becoming more and more intertwined with technical innovations. Said innovations can be characterised by profound interconnectivity, constant and accelerating change, and an economy underpinned by valuable flows of information and data. I postulate that this interconnectivity, changeability, and mobility of capitalist ideas enables the restrictive exercise of ideational power – which limits critique's emancipatory potential (Carstensen & Schmidt, 2016; Larsson, 2018) within urban waste governance systems. Hence, an interdisciplinary approach is crucial if we are to produce practical, strategic, and theoretically relevant research outcomes. Mono-disciplinarity leaves the institutionalised root causes of commodification in urban waste governance systems unaffected. To effectively bridge practical and theoretical relevance in this thesis, there is an opportunity and a need to combine both academic and other types of knowledge in the delivery of research outputs.

Secondly, an analytical emphasis on the interconnected and systemic nature of global capitalism and its commodifying logic must not detract from the distinct regional or local contexts in which commodification influences socio-environmental outcomes; nor should such a wide lens preclude a consideration of the role of decentralised power. These global and local scales should be interwoven by examining how institutional arrangements are presently structured in individual cities (thus appreciating empirical context), without losing sight of similarities and divergences between different cities to illuminate why and how apparent causes and effects recur or persist. Considering that the question of whether and how circular economy and food-energy-water nexus ideas affect policymaking processes and outcomes is related to whether and how institutionalised

interests express these ideas through discourse, it might be instructive to consider place-specific context in answering said question. Whilst there is insightful literature dealing with overt issues of scale in environmental governance (Bulkeley, 2005), less is said about substantive discourse and how it relates to place-specific political contestation (Cowell et al., 2020; Koch et al., 2021). More specifically, I argue that we do not know enough about how specific (substantive) branches of environmental governance – such as waste governance in cities – interact with highly technical discourse that may serve institutionalised capitalist interests seeking to maintain their dominance.

Thirdly, there is an opportunity to combine or mix quantitative and qualitative methods to capture both the structural and agentive aspects of institutionalised behaviour. The literature points to a gap in this regard, wherein qualitative research designs tend to emphasise intentional or reasoned behaviours at an individual level whilst quantitative research designs tend to focus on unintentional behaviours at group level. In this thesis, I attempt to combine quantitative and qualitative methods in answer to cutting edge literature that calls for research designs which try to account for the complex interplay between structural and agentive aspects of individual and group behaviours (Tikly, 2015; Stutchbury, 2022). Thus, in this study, I attempt to encompass both agentive and structural institutionalisation in urban waste governance systems (Koch et al., 2021). To find meaning in the high level of complexity that comes with such an approach, multiple cities are included to produce transferable lessons for urban waste governance policy.

Lastly, a substantive element of critique in the analysis of commodification in urban waste governance fills both practical and theoretical gaps. It offers an opportunity to fill a practical gap since effective critique can counteract the central research problem introduced above. Critiques that convey emancipatory intent and reject domination can enhance waste governance in cities by foregrounding inequalities of wealth and power. This can improve the processes and outcomes of institutionalisation and policy around waste in cities. In turn, substantive inclusion of critique in this research design offers an opportunity to combine the respective strengths of environmental governance theory and critical institutionalism theory. The basic common ground between these theories is their unfolding argument that discourse matters. However, there is a lack of literature emanating from research designs which bring a critical approach to the operation of discourse in processes and outcomes of urban waste governance and policy in a capitalist context. This gap is explicit in literature that attributes the disintermediation of effective critique and social movements from governance and policymaking processes and outcomes to a flawed global capitalist social system (Boltanski & Fraser, 2021). Based on these gaps, three specific research questions emerge. I list said questions in the next section. The research questions are followed by

an introduction to the scope, potential contribution, and lastly the structure of this thesis. For more detail on how my reading of the literature influenced the overall research design, see Chapter 2.

1.8 Questions

1. **What is the composition and structure of urban waste governance systems wherein the circular economy and food-energy-water nexus concepts have become institutionalised?**
2. **How does ideational power relate to emancipatory institutional change in contemporary urban waste governance; and what does this mean for social-environmental challenges?**
3. **What factors influence the process of institutional change in urban waste governance systems; and what compositional or structural outcomes emerge over time as a result?**

1.9 Scope

The scope of this research is the waste sector in three cities: 1) Cape Town, South Africa, 2) Rotterdam, The Netherlands, and 3) Bristol, United Kingdom. I specifically focus on the policy, discourse, and relations that link institutions and that might shed light on the proliferation of commodification in urban waste governance. The research was undertaken from 2019 to 2022. The demographic of persons invited to participate in the qualitative data collection process included business, government, academic, third sector, and financial professionals whose physical or intellectual work involved waste in these cities. I elaborate on sample selection in Chapter 3. Topical themes include the social, economic, and political aspects of urban waste governance. To illustrate, the social theme includes topics such as cooperation and social justice. The economic theme includes topics such as inequalities of financial distribution, and the role of money more generally. And, lastly, the political theme of waste governance includes topical questions such as where decision-making power is concentrated, and whether such decision-making is democratic.

It is with inspiration from Boltanski & Fraser (2021: pp. 25, 28) that this multi-thematic approach is taken in setting the scope of my research: the commodification of urban waste governance is investigated through an empirical critique of "*new structures of power and those who are invested in them*". In particular, I hope to make a unique contribution with this research by critiquing the commodification in urban waste governance as an attempt to decouple "*capitalism's drive for limitless expansion*" from the limited capacity of the natural world to sustain capitalism's logic.

1.10 Contribution

Waste governance in cities and global social-environmental issues are often dealt with separately. But as the world becomes more inundated with information and as its crises become more interrelated, complex, and interconnected (Fraser, 2021), effective narratives are important (Koch

et al., 2021). In narrative terms, environmental degradation is now widely accepted as a global crisis (Wunderling et al., 2022), as is economic inequality (Piketty, 2015). But, if the root cause of these problems is systemic and structural, popular imaginaries of how our social systems and structures might need to change to avert crises may be constrained. Thus, "*narrative congruence*" is a problem (Koch et al., 2021). This is by no means a far-fetched "*may-be*". Boltanski & Esquerre (2017) directly critique the evolution and increasingly all-encompassing logic of commodification in contemporary capitalism. When it comes to waste and its governance in urban societies, the stakes are higher than outcomes like conventional economic redistribution or the reduction of pollution rates. The governance of waste in cities, as a niche example of urban environmental governance, may be actively driven by, and ultimately may itself be fueling, an all-pervading logic of commodification. In an era of information technology and disintermediated dissent or contestation in social movements, this logic may be eroding the actual effect of critique.

This matters because the power in ideas like "circular economy" and "food-energy-water nexus", which have the potential to discursively reinforce or prolong histories of inequitable enrichment through commodification in urban environmental (waste) governance systems, demands effective critique. And because, in the context of a global society inundated with information technology and mass media, popular ideas can be amplified and twisted to restrict imaginaries of more radical alternatives. The consequences of the antithetical scenario, where *in*effective critiques, and ideas such as a "circular economy" or "food-energy-water nexus" in particular, are perhaps becoming institutionalised in urban waste governance, go beyond simply reducing pollution (or not) and redistributing wealth (or not). It matters for the construction of our social reality (Boltanski, 2011).

The interdisciplinary theoretical framework I will present in Chapter 2 and apply throughout this thesis responds to this context. It foregrounds the emerging and inextricable *interconnectedness* between environmental governance systems and social reality; now, and in the future. This is an academic reflection of the interrelatedness of tangible and practical challenges humanity faces that has been considered and built into my research design. My choice of analytical and conceptual frameworks (which are also presented in Chapter 2 and operationalised throughout this thesis) reflects the important contextual and systemic nature of these challenges; and of the transforming locus, form, and roles of critique in our information-age relational social structures. We cannot ignore the function of effective critique (Delmas, 2018; Boltanski & Fraser, 2021).

Besides aiming to meaningfully bridge different theories and different spheres of thought, this research contributes by employing a mixed methodology. More specifically, as I explain in Chapter 3, I integrate both social network analysis and qualitative analysis with agent based modelling. Social network analysis mainly serves to answer my first research question (linked to

the first research objective), qualitative analysis mainly serves to answer my second research question (linked to the second research objective), and agent based modelling mainly serves to answer my third research question (in turn, linked to the third research objective). Each method complements the others (Figure 6) and partly answers all research questions, as does my literature review. Each research question corresponds to a particular research objective and hypothesis. This study's contribution to theory and policy is extended by foregrounding power asymmetries in urban waste governance systems. I hypothesise that the processes and outcomes of institutional change, with contextual reference to waste in cities, result from and affect existing relations of power between diverse institutions comprising these systems. It is this prospective contribution that motivates my complex, but purposeful, mixed method methodology. Triangulation has been effectively applied in critiques of power imbalances (Kezar, 2003; Richardson, 2014). As argued elsewhere, singular environmental challenges like urban waste cannot be effectively resolved separately from broader, closely related social-systemic crises in capitalist society (Nixon, 2011).

This study also contributes by linking not only interrelated crises of environmental degradation, disempowerment, and inequality by combining theories and modes of thought, but also by linking the world-wide scale of underlying causes and the city-specific scale where their effects manifest.

1.11 Structure

Chapter 2 elucidates and critiques selected ideas (circular economy in Section 2.1.1 and food-energy-water nexus in Section 2.1.2) and theories (environmental governance in Section 2.2.1 and critical institutionalism in Section 2.2.2), and it assesses their relevance. This then informs a critical discussion of whether these ideas and theories should change and, if so, how (Chapter 5).

Chapter 3 explains the research methodology, methods, as well as procedures followed to collect and analyse data. In Section 3.1, I outline the overall methodology and justify its appropriateness to test the hypotheses and answer the research questions. Then, in Section 3.2, I present my rationale for a comparative city-scale case study. In Sections 3.3 to 3.5, I set out the sequence and interdependencies of the social network analysis, qualitative analysis, and agent based modelling phases of my data collection and analysis process. In Section 3.6, and at the start or end of each respective method section, I explain the process of – and reasons for – integrating these methods.

Chapter 4 presents results obtained from i) the social network analysis which includes graphical representations of the waste governance system appraised for each city (Section 4.1), ii) qualitative analysis which interprets interviews with key representatives (Section 4.2), and iii) agent based modelling which includes visual and textual representations of an explanatory agent based model calibrated for each city (Section 4.3), and iv) their triangulation (throughout Chapter

4). City-specific calibration follows explanation of procedures and outputs derived from a sensitivity analysis exploring my model's dynamics in Section 4.3.1. In Appendix A, I provide the agent based modelling code that was produced specifically for the purposes of this research.

To synthesise the research outcomes, Chapter 5 discusses theoretical and practical implications, and revisits the key assumptions which informed my research design vis-à-vis findings obtained. This chapter also reflects on the suitability, relevance, and adequacy of all the methods employed in combination. Specifically, in Section 5.1, I answer each respective research question and reflect on the findings relevant to each answer. In Section 5.2, I elaborate on the answers to the research questions by testing each respective hypothesis linked to each research question against the thesis' findings. And, in Section 5.3, I reflect on important limitations applicable to the research design.

In Chapter 6, I synthesise the overall findings and research outputs to encapsulate the thesis. I present a concise summary of the theoretical and practical implications of key findings with recommendations for future research as well as policy – all of which may in turn warrant critique.

2 Literature Review

This chapter serves two purposes. The first purpose is to elucidate and critique, firstly, the ideas of a circular economy and food-energy-water nexus, and, secondly, environmental governance theory and critical institutionalism theory. The second purpose is to provide an assessment of their relevance, and to reflect on whether these ideas and theories should be amended, and, if yes, how. In the first half of this chapter, analytical (systems thinking) and conceptual (context in the interaction of research and government policy) frameworks are applied to understand the power in the concepts of i) a circular economy, and ii) a food-energy-water nexus. In the latter half of this chapter, consisting of two subsections, I elucidate and critique environmental governance theory and critical institutionalism theory respectively using the same analytical and conceptual frameworks, but with an interdisciplinary modus incorporating critical sociology. It is with these transdisciplinary (analytical-conceptual) and interdisciplinary (theoretical) approaches that I aim to constructively critique environmental governance theory and critical institutionalism theory.

In Section 2.1.1, I present a definition and applications of the circular economy concept. Then, I appraise its emergence in mainstream political and commercial discourse. Subsequently, I critique its apparent contribution to understandings of waste as a commodity. And I situate the circular economy in the context of complexity, diversity, and dynamicity characteristic of contemporary environmental governance systems in cities (Rhodes, 1997; Kooiman, 1999). I problematise the ineffectuality of critical social movements in circular economy discourses, transcending national and class categories across and within different cities under study. Further, I note the discursive evolution of the circular economy concept away from civic and ecological evaluative criteria; reinforcing, to my mind, the need to critique waste commodification in a context of an intertwined social-environmental crisis. Lastly, I consider the political impotence of radical circular economy discourse in light of environmental degradation, economic inequity, and democratic recession; and this perspective motivates my critique of institutionalising urban circular economy networks.

In Section 2.1.2, I present a definition and applications of the food-energy-water nexus. Then, I problematise the food-energy-water nexus idea's discursive reinforcement of the relational and interdependent nature of contemporary environmental governance systems in cities. Next, using secondary sources, I argue for the appropriateness of social network analysis to critique the composition and structure of urban environmental governance systems. Then, also situating the food-energy-water nexus in a contemporary context of complexity, diversity, and dynamicity, a conjecturally positive correlation emerges between interconnectedness and capacity in urban environmental governance systems. This partly informs the design of my agent based model in

Section 3.5. Relatedly, I substantiate the suitability of methodological pluralism. Next, as with the circular economy concept, I identify equity as an important gap in the food-energy-water nexus literature. But, also, I critique the concept by transcending consumeristic paradigms and exclusionary decision-making processes using my transdisciplinary framework. That is, by applying the systems thinking analytical frame and the "context in the interaction of research and policy" conceptual framing, I critically analyse the food-energy-water nexus concept's risk and potential in terms of contemporary environmental governance policy and its known pitfalls. Lastly, I substantiate the need for empirical approaches, in addition to systems approaches and modelling, in my critical analysis of the food-energy-water nexus in cities by admitting a need to address the vital "*role of institutionally mediated human agency*" (Allouche et al., 2019, p. 82).

In Section 2.1.3, I present a summary of preceding sections and integrate the respective concepts.

In Section 2.2.1, I critically analyse environmental governance theory. As with the two concepts dealt with in Sections 2.1.1 and 2.1.2, I firstly situate environmental governance theory in a contemporary context of complexity, diversity and dynamicity; departing from, and elaborating on, the original definition of governance adopted in my research (Rhodes, 1997; Kooiman, 1999). Then, moving on from environmental governance's interactive and networked nature in turbulent contemporary contexts (Cowell et al., 2020), I consider the relevance of "narratives" and social structure for environmental governance systems (Koch et al., 2021). Approaching a synthesis of the two bodies of theory comprising the theoretical framework of this study, I aim to advance a critique of "institutional work" in environmental governance (Beunen & Patterson, 2019). I recapitulate the reasoning behind such a critique with reference to my methodological design and its rationale. Finally, I briefly review the concept of bricolage (alongside that of institutional work) and justify my decision not to adopt either of these in analysing my subject matter.

This leads, in Section 2.2.2, to the unprecedented degree of reflexivity and adaptability which characterises systemic reasons for this era of interrelated social-ecological crises (Fraser, 2021). Specifically, I concur that said systemic reasons revolve around a newly holistic notion of capitalism (Fraser & Jaeggi, 2018), with its pervasive and evolving logic of commodification (Boltanski & Esquerre, 2017). Next, advancing the topic of agentive institutionalisation of certain (capitalist) ways of doing and knowing, I problematise the lack of critique in environmental governance (Boltanski & Fraser, 2021). This problematic is informed by critical institutionalism theory, which I elucidate. Then, I justify my selection of a particular strand within critical institutionalism theory to critique environmental governance theory. To do this, firstly, I define and narrow down ideational power (Carstensen & Schmidt, 2016). Then, I provide my main reasons for declining alternatives, such as discursive institutionalism (Whaley, 2018), opting for

a particular strand within critical institutionalism theory selected for this research. Over and above the substantive reasons for declining relevant alternatives, I put forward my justification for a transdisciplinary framework to reinforce my rationale for selecting the specific strand of critical institutionalism in question. Lastly, in this section, I also elaborate my interdisciplinary theoretical framework chosen in this research to justify borrowing and combining certain concepts from other institutionalisms (Hay, 2016; Larsson, 2018; Lok, 2019) and critical sociology (Boltanski, 2011).

In Section 2.2.3, I summarise and relate my research- and methodological design to the literature.

2.1 Circular economy & food-energy-water nexus concepts

2.1.1 Circular economy

The circular economy (CE) is promoted by the European Union and a variety of economically influential governments. It is supported by large businesses around the world (Korhonen et al., 2018). There are many definitions of a CE. As this study analyses different research sites (Section 3.2), some of which are in Europe, the European Environment Agency's description is useful: "[a CE] *is a set of regenerative and cooperative activities that ultimately reduce natural resource extraction*" (EEA, 2016, p. 9). Chiappetta Jabbour et al. (2020) define it as a system of production and consumption which aims to i) optimise the use of resources and waste by means of closed-loop, regenerative, and shared approaches, and ii) avoid unnecessary consumption of natural resources (*e.g.*, energy, water, and materials) and waste by optimising processes of exchange and technological change. This definition reflects a normative theme revolving around economic and material *optimisation* in the wide ranging literature engaging the CE concept (Parsa et al., 2021).

Likewise, Schroeder et al. (2018) observe that the CE concept is often defined in terms of actions and practices that range from reuse and recycling to product sharing and industrial symbiosis (Spilhaus, 1968). This normative (re)collection of known actions and practices suggests that the value of CE as a concept may lie in its discursive potential to galvanise a critical mass of established economic interests in favour of cooperative efficiency, rather than in its ability to inform and direct fundamental institutional change in existing urban environmental governance systems (Blomsma & Brennan, 2017). The complex challenges posed by the ever-growing concentration of people in cities, and concomitant questions about what kind of a pattern would result if one were to plan major cities for maximal productive and consumptive efficiency, are not new (Haig, 1926); nor is the idea of closed loop systems in industrial innovation new (Murray et al., 2017). This lack of novelty foregrounds an important weakness of CE: its emphasis on productive and consumptive efficiency within an existing capitalist model. This may be one of the reasons why CE ideas are politically and economically popular (Lacy et al., 2014): because it does not destabilise already institutionalised concentrations of economic and political capital. But,

paradoxically, it is perhaps also such tacit acceptance of economic and political status quos that limits its value in terms of, for example, the achievement of meaningful and systemic change in political economics (Bianchini et al., 2018). Its transformative potential is undermined by the risk that its universal adoption may paradigmatically sustain a systemic *business as usual* (Mah, 2021).

CE's emergence in academic, commercial, and political discourse is prevalent in influential economies such as those in Europe, the USA, China, Japan, South Korea, Canada, Australia, and New Zealand (Ghisellini et al., 2016; Ranta et al., 2018). Ghisellini et al. (2016: p. 18) argue that "*CE efficiency and environmental protection would become crucial factors to orient policies for the transition to new production and consumption patterns*", rather than CE constituting the new production and consumption pattern in and of itself. But, crucially, resource scarcity motivating CEs should not only be a matter of physical or material efficiency, but of social reproduction and equity (Mavropoulos & Nilsen, 2020). Further, the need for new, equitable production and consumption patterns is arguably so urgent that gradual improvement is inadequate. To illustrate this, "*working-class people in the UK are more likely* [than non-working class people in the UK] *to experience environmental deprivation in terms of air pollution, transport, and proximity to landfill sites, flood risk, food poverty, fuel poverty, and access to green space*" (Bell, 2020, p. 19).

For example, in Bristol, Reed & Keech (2019) critically engaged with the concept of smart cities, arguing that the cutting edge of food policy in the UK can be understood as a *social movement* – but, they argue that the diffusion of post-material values and revolutionary axioms like the right to food and sustainable diets is hampered by capacity constraints in ordinary local government *politics*, coupled with its apparent distance from willing and able third sector expertise. Extending this example of sustainable food, a niche application of a CE, it is now an urban rebranding tool in The Netherlands, whereby the city of Rotterdam is reinventing itself as a "*sustainable world harbour city*" (Gemeente Rotterdam, 2011, p. 75) to attract wealthy people and elevate the city's status and appeal beyond that of an industrial hub (Cretella & Buenger, 2016). Besides this campaign, Rotterdam (and The Netherlands more broadly) has been identified as a leader in the institutionalisation of CEs across Europe, making it a key example of the CE's institutionalisation in powerful economies around the world (Ranta et al., 2018; Mazur-Wierzbicka, 2021). In South Africa, where energy policy is persistently problematic, Cape Town has long been "*a leader in embracing a sustainable development agenda at a policy level*" (Greyling et al., 2016, p. 52). But, in a study on urban energy policies, Jaglin (2013) argued that multi-scalar interactions between government and social movements here tend to involve chaotic and messy power struggles and patterns of dissent, as opposed to stable processes of fair cooperation. These examples of food and energy policy illustrate how complex, diverse, and dynamic environmental governance

systems are. The strategic nature of the CE concept (Parsa et al., 2020) raises concern that it can "*extend and protect* [unsustainable] *markets*" or advance the corporatisation of environmental governance by discursively legitimising waste recycling downstream and wasteful production upstream (Mah, 2021, p. 123). This legitimisation depends on CE discourse's non-political character, which may be partly responsible for CE's limited transformative potential (Valenzuela & Böhm, 2017).

Related concerns include the CE's perceived neglect of equity, which has been widely critiqued. In search of remedies to said concerns, principles and values that drive social and solidarity economy initiatives are being touted as preferred solutions to the lack of social concern in mainstream (recycling) CEs, "*particularly in relation to 'externalities' and the need for political reform*" (Moreau et al., 2017, p. 498). Other scholars seeking to alleviate concerns around CE's perceived neglect of equity argue that social and cultural capital are crucial for the stimulation and management of systemic change in cities (Avelino & Wittmayer, 2016; Bouzguenda et al., 2019; Fowler, 2020; Raimbault et al., 2020; Samson, 2019). And, with the presumably similar intention to foreground equity, new literature which attempts to redirect CE discourse toward the interrelated nature of social and environmental crises is emerging (Temesgen et al., 2021). The widening intra- and international inequalities between the European Union, North America, and the rest of the world (Piketty, 2015) attest to the pitfalls of relying on self-regulated circularisation of linear economies. If low-income countries achieve their developmental goals by strategically "bending" existing economic consumption and production patterns, it will result in correlating increases in waste (Kaza et al., 2018). But, also, if newly empowered metropolitan governments in poorer settings emulate the CE in wealthier nations, there is a risk that both structural power imbalances and waste streams will be reproduced (Corvellec et al., 2022). Despite deep inequities in poorer settings, CE discourse can perpetuate the lack of social responsibility and environmental concern that persists in *laissez-faire* implementations of plastic recycling schemes (Perez, 2021).

In Europe, there is mounting concern that, especially in the context of turbulent international and inter-regional trade and relations, waste governance systems are becoming an exclusive political arena where public policy is being privatised (Flynn & Hacking, 2019; Cowell et al., 2020). This concern may be indicative of growing interdependence between business and government policy. Using the UK's brittle post-Brexit relationship with the European Union as a case study, Cowell et al. (2020, p. 5) find that commercial stakeholders argue explicitly for "*the clarity and institutional durability that EU alignment conferred*". There is explicit commercial resistance to institutional change in the waste governance system of the United Kingdom, in this case, because significant change would disrupt continuity in international trade. Indeed, applying Boltanski &

Thevenot's (2006) critical theory of justification, Cowell et al. (2020) collected qualitative data suggesting that critiques of disrupting established international waste trade in Europe subordinate ecological values to economic values in articulating resistance to such change. This is not to say that circular economies in Europe are simply neoliberal, free-market manifestations of capitalist logic. Rather, Cowell et al. (2020) also provide evidence suggesting that the EU waste industry is wholly dependent on internationally aligned regulatory mechanisms.

This apparent interdependence between business and government signifies a particularly difficult challenge stemming from the institutionalisation of circular economy networks. As the waste industry grows, institutional inertia accumulates and potentially makes it difficult for critical thinking to affect policymaking processes. Further, as academic pursuits (where one might expect critical thinking to flow from) often rely on funding from governments or big businesses, there is a risk that the research designed to inform and influence government policy becomes expurgated. Cowell et al. (2020) similarly argue that this trend, with specific reference to the circular economy in Europe, risks disintermediating dissenting institutionalised powers like devolved governments. Importantly, and the significance of this point will become clear later in this thesis, Cowell et al. (2020) highlight the heterogeneous nature of urban environmental governance systems as well as the central role of semantic trends for critical analysis of the trajectory of institutional change in those. Where this important and valuable research falls short, however, is in the assumption that the diverse, complex, and dynamic nature of environmental (waste) governance systems tacitly imply opportunities to contest the established social structures upon which CEs grow. If the CE becomes a semantic vehicle for interests coveting continuity of unsustainable (growth-oriented) capitalism, it cannot change *systemic* and *institutionalised* outcomes of such systemic economic continuity such as environmental degradation, economic inequality, and democratic recession.

Considering the interdependence of regulation and trade in contemporary contexts (Flynn & Hacking, 2019), the often apolitical tone of CE *discourse* is therefore understood as a weakness. Coupled with a potential disconnect between effective critical thinking and dissenting social movements (Boltanski & Fraser, 2021), the *apparent* political impotence of CE discourse is a problem. It is possible that the anti-political, or undisruptive, institutionalisation of CEs is contributing to the maintenance and reproduction of existing, unequal social structures in cities. Particularly, the unquestioned commodification of waste materials, which CE discourse catalyses, toes the longstanding line of capitalist logic. The CE is broadly implicated in commodification by virtue of it providing a pathway through which monetary value is assigned to a growing variety of phenomena. This has been critiqued by scholars such as Greer et al. (2021) and Valenzuela & Böhm (2017) who foreground the different ways in which the CE discursively justifies and

perhaps even sanctions the continued enjoyment of mass-consumption and its production of waste in a familiar but evolving capitalist society. To counter this, more radical representations of CEs could be brought into policy-making processes which affect the process of institutional change in waste governance systems. However, such counteraction may be understood more generically as the promotion of *effective* plurality in decision-making fora where waste governance is regulated.

2.1.2 Food-energy-water nexus

The nexus concept gained momentum through various major international conferences that focused on resource management viewed through an economic lens. Most notably, it was foregrounded at the 2009 World Economic Forum (Waughray, 2011) and Bon11 Nexus Conference (Hoff, 2011). This FEW nexus as a systems thinking approach connects the closely interrelated domains of food production (and security) for human consumption, freshwater retention and distribution, and energy generation and usage. Huntington et al. (2021) define the FEW nexus as a conceptual tool which analytically emphasises the interdependencies between sectoral domains and thus fosters material efficiencies. Importantly, Huntington et al. (2021) caveat this with the proviso that the material nexus between water-, energy-, and food systems does not necessarily outweigh other factors (such as governance) in the determination of human well-being – an outcome which may warrant more attention. This concept has developed because of a remarkably widespread consensus that global society is approaching a disastrous scarcity. But, as pointed out by Waughray (2011), the idea that different elements of complex systems are interconnected, and that we cannot effectively think of these separately, is not new (Muir, 1911). Traces of systems thinking and its application to natural and social systems are thousands of years old (Lal, 2016). To appreciate the food-energy-water nexus as it is applied in this thesis, attention must be paid to its international popularisation over the last decade (Romero-Lankao et al., 2017). Recently, a niche focused on FEW nexus governance and discourse has emerged, drawing lessons from applications of this concept in unique places (Urbinatti et al., 2020; Huntington et al., 2021).

Similar to Koch et al.'s (2021) combined application of narrative analysis and social network analysis to understand processes of institutional change in environmental governance systems (see Section 2.3), Urbinatti et al. (2020) combined social network analysis and discourse analysis methods to analyse the conceptual basis of food-energy-water nexus governance using a systematic literature review. In this review, important findings were produced, including the identification and isolation of known but divergent challenges surrounding the food-energy-water nexus and its governance. For example, Urbinatti et al. (2020) referred to a plethora of secondary sources which problematise the technical-financial-material lens through which nexus problems have been framed (Mohtar, 2016; Daher et al., 2018). The methodological pluralism (Stirling,

2015) applied by Urbinatti et al. (2020) is a useful and innovative precedent; I aim to learn from and further enhance their approach in this thesis as detailed in Chapter 3.

The transversal food-energy-water (FEW) nexus concept emerged in the last decade as a response to an acknowledgement of the interrelatedness of food, energy, and water governance systems, and the imperative of addressing their challenges in a holistic way (Allouche et al., 2014). Its institutionalisation has been fuelled by a growing popularity among academics, businesspeople, and policymakers (Leck et al., 2015). Akin to the critique levelled against CEs in the previous section, there is already literature critiquing apparent "*governance gaps*" which render the FEW nexus "*disconnected from the decision-making and policy-making processes it ultimately seeks to influence*" (Weitz et al., 2017, p. 165). Contextual heterogeneity, including different laws and policies, economic and societal structures, and biophysical environments within which distinct agents traditionally operate, can lead to haphazard or fragmented FEW nexus governance. In such settings, where such a variety of contextual factors are at play across sectors, consensual decision-making can become challenging (Kurian et al., 2018). A distinguishing characteristic of nexus research is its explicit prioritisation of multiple forms of trade-offs and coordination that do not only involve the sharing of financial or material resources between discrete institutions. These trade-offs and coordinating efforts also extend to the sharing of data, human resources, and intellectual property between public, private, and third sector institutions (Kurian et al., 2018).

In order to link the FEW nexus concept more directly with contemporary forms of governance (Rhodes, 1997; Kooiman, 1999), we might consider the similarities of its integrative logic and the interrelated, interactional, or web-like nature of governance systems (Urbinatti et al., 2020). But the process of making trade-offs, of institutional change or rearrangement in environmental governance systems, involves active power struggles wherein established institutions might be expected to start with significant advantage (Beunen & Patterson, 2019). This is not necessarily a problem. But new research warns that the urban waste commodity frontier can cause path dependency on perpetual streams of waste, thereby incentivising wastefulness for economic purposes and, potentially, further institutionalising systemic inequalities (Samson, 2020; Greer et al., 2021). If FEW nexus relationships evolve with the purpose of facilitating exchange of freely available and high quality recyclable material, established institutions can thus multiply their exploitation of this resource. This is a problem not only because multiplying the value of waste streams reinforces their existence by incentivising their longevity, but it also crystallises capitalist logic (Allouche et al., 2019). Other problems with the FEW nexus include a vague conception of governance, a lack of inter- and transdisciplinary approaches that link systems thinking with policymaking (Bazilian et al., 2011), and a lack of critical-discursive focus (Urbinatti et al., 2020).

Kurian et al. (2018), in a study using social network analysis to map the FEW nexus in action, find that there is a correlation between institutional capacity and interconnectedness of FEW nexus networks. But, again, this understanding of the FEW nexus operates at a high level of abstraction wherein the "*critical voices of egalitarianism*", and the basic imperative of plurality required to provide a platform for such voices, go unaccounted for (Allouche et al., 2019, p. 79). Mercure et al. (2019) highlight the role of global environmental and economic change and its impact across sectors (*e.g.*, energy, agriculture, water) and scales (*e.g.*, federal, state, municipal). In concluding, their research expresses a need for consolidated and improved understanding of the dynamics involved in each of the multi-stakeholder policymaking processes that should be, but are not, informed by research (Mercure et al., 2019). Mercure et al. (2019) suggest utilising more stochastic modelling approaches which might account for messy learning curves wherein stakeholders play fluid, temporary roles, and to critically consider systemic FEW nexus dynamics. So, whilst high-level social network analysis of the FEW nexus suggests that, in aggregate, more linkages or a higher number of cooperative relations in a waste governance system correlates with more overall capacity to deal with waste, a critical consideration of the composition and structure of such networks may enable us to account for structural causes of waste which maintain inequity. To illustrate this, Allouche et al. (2019: p. 80) point to the very disagreeable, systemic "*waste of almost a quarter of all fresh water*, *crop area, and fertiliser currently used for food production*".

It is important to take stock and qualify the critique levelled against the FEW nexus concept thus far, as well as of the critique against the CE concept. Neither of these are intrinsically problematic nor necessarily unfit for incremental institutional changes in urban waste governance systems that enhance our capability to address interlinked social-environmental challenges. Rather, the seeds of the strong element of critique in the design of my research can be found in the conclusion to Allouche et al.'s (2019) book – where four challenges are highlighted: as with the CE, we must reflect on the i) capitalist logic pervading FEW nexus discourse, ii) resistance to deeper change through the restriction of imaginable alterity, iii) persistent lack of effective plurality in policymaking processes, and iv) lack of radical approaches (Allouche et al., 2019, pp. 131-133).

Up to this point, the CE and FEW nexus concepts have been primarily critiqued considering the insights from environmental governance theory, which is dealt with respectively in Section 2.2.1. But, likewise, they can also be critiqued in terms of critical institutionalism theory, which is dealt with in Section 2.2.2. As implied in Allouche et al.'s (2019) warning, a critical-discursive focus on the CE's and FEW nexus' effects on social equity is currently missing in much of the literature. More specifically, there is a lack of attention paid to "*the role of links between* [FEW sectors] *at larger scales in determining resilience, and for whom*" (Stringer et al., 2014, p. 15). It is this

shortcoming in both CE and FEW nexus which motivates my interdisciplinary combination of environmental governance theory and critical institutionalism theory in this study. Particularly, it is the latter theory's inherent requirement to critique systemic asymmetries of power and status quos against which institutional change is justified or evaluated which I consider as appropriate to address the above mentioned gap in the literature (Knight, 1992; Bromley, 1993; Vira, 1997).

My research reflects on the four challenges highlighted by Allouche et al. (2019) in the following ways: first, I focus on the power *in* ideas (Carsternsen & Schmidt, 2016) imbued with scientific and pragmatic authority as they manifest in discourse – a focus which enables a critique which concentrates on the restriction of alterity. Second, this restriction of alterity is explicitly related to capitalist logic's permeation of CE and FEW nexus discourse. Third, my transdisciplinary analytical-conceptual framework is geared to address a lack of effective plurality in policymaking processes relevant to the institutionalisation of the CE and FEW nexus concepts in urban waste governance systems. Fourth, and finally, the imperative of critically investigating "*institutionally mediated human agency*" in addition to systems analysis and -modelling is designed into this research through methodological pluralism – or a mixed method methodology comprising social network analysis, qualitative analysis, and agent based modelling (Allouche et al., 2019, p. 132). And, whilst the link between a topical focus on the commodification of waste in cities and the CE is perhaps more obvious, the link between that topical focus and the FEW nexus is less obvious.

Cutting edge literature on the FEW nexus is calling for more critical angles which bring nexus governance into the spotlight (Urbinatti et al., 2020). In particular, such a critical focus on the FEW *nexus* can demonstrate why, in addition to and distinct from the CE concept, it has been selected for the purposes of my research. A powerful feature of the FEW nexus concept, as Huntington et al. (2021) usefully explain, is the fact that it stimulates us to push the contours of systemic analyses outward. It drives the analyst to think more holistically about an interdependent food-water-energy system – as opposed to thinking about each of those sectors in isolation. Such holistic thinking, as D'Odorico et al. (2018) argue, fosters synergistic strategies that can provide increased security of (food, water, and energy) provisions to sustain growing human consumption. In this way, the institutionalisation of the FEW nexus concept (which is, arguably, not as advanced as that of the CE concept) prolongs the problem that motivates my research aim in this thesis. Waste commodification is broadly understood as a manifestation of capitalism's forward march – and capitalism is understood as a social *system*. The FEW nexus concept's institutionalisation reinforces that system by maintaining the illusion that infinite consumptive growth is sustainable. Scholars such as Kaika (2017) and Dornelles et al. (2020) make important contributions in this regard – cautioning against concepts and practices that make the wrong sorts of systems resilient.

2.1.3 Summary

There are two points of emphasis which relate my focus on both CE and FEW nexus concepts to the research problem, -aim, and -objectives. First, the CE concept and its overtly economic nature illuminates the commodifying logic intrinsic to modern capitalism and how that permeates urban waste governance systems. This permeation is complex, and it is expected to manifest differently in different real-world contexts, especially considering the inherently complex nature of how institutions emerge, persist, and become or remain dominant in urban waste governance systems. Second, the FEW nexus concept and its overtly inter-sectoral nature aligns with the decentralised structure and composition of urban waste governance systems in an age of rapid information and communication technology development. Understanding the structure and composition of urban waste governance systems can be instrumental for a bolstered element of equity in their operation. The themes of interdependence and regulatory alignment emerge from my reading of literatures dealing with both CE and FEW nexus institutionalisation in regional and international governance systems. And, rather than a reductive assessment of both or either of these ideas as being nothing more than conformist concepts that pine to capitalism and its characteristic asymmetries of power – my reading suggests they disrupt existing supply chains but conform to deeper social structures.

Therefore, understanding the commodification of waste as it shapes and is shaped by processes and outcomes of institutionalisation in urban waste governance systems, with specific reference to the CE and FEW nexus as examples of ideas with political traction, requires significant nuance. Such nuance might be gained from an intensive analysis of how urban waste governance systems are structured, how institutions within those systems relate to one another, and what the profile of power ultimately looks like as a result. Painting such a picture may be a never-ending work in progress since social and economic life never stops developing. The disruption of existing supply chains happens ongoingly when, for example, two historically separate sectors or industries come together and exchange waste as a resource to produce something new or make production more efficient. But there is an immaterial (social) aspect to economic life which I argue is predominated by capitalism *as a social system* which tends to be thought of in purely economic terms. Herein, it seems to me, lies the appearance of complex conformity to deeper social structures identified by the literature on CE and FEW nexus institutionalisation in urban waste governance systems. If we pay critical attention to the discursive dimension of this process – and structural outcomes that can be associated with this process – we may understand whether and how the proliferation of these ideas in waste governance discourse contributes to emancipatory transformation in society.

The extent to which and the way the CE and FEW nexus concepts have become mainstream in political, practical, and academic discourses are expected to differ. However, taken together, my assessment of the proliferation of these ideas suggests that there is a risk that the combined logic

of commodification (as implied in the expansion of "waste as a resource" for the development of CEs) and consolidated urban waste governance systems (as implied in the FEW *nexus* between wasteful industries / sectors and the generic waste management or recycling industry / sector) can perpetuate or even exacerbate the systemic causes of interrelated social- and environmental crises.

2.2 Theoretical framing

In sections 2.2.1 and 2.2.2, I articulate and integrate environmental governance theory and critical institutionalism theory as the interdisciplinary theoretical framework for the purposes of this thesis. Specifically, in Section 2.2.1, I critically review environmental governance theory with a focus on its structural emphasis and the potential asymmetries of power which may ensue. This assessment is dovetailed by my critical review of critical institutionalism theory in Section 2.2.2, which emphasises its untapped potential for application to real world spheres of practice like the governance of waste in cities. I summarise the integrated theoretical framework for this thesis in Section 2.2.3. That summary can be read as the rationale for the combination of these two theories.

2.2.1 Environmental governance

Before specifically dealing with environmental governance theory in this section, it is necessary to pin down the concept of governance. Rhodes (1997: p. 653) understood governance systems as "*self-organising, inter-organisational networks*", whose function had begun to supplant that of the traditional forms of government, *i.e.*, "*authoritatively allocating resources and exercising control and co-ordination*". Today, this understanding of governance is arguably even more relevant. In the context of a globalised society mediated by information and communication technologies, the meaning of democratic participation is changing (Harari, 2016). People and collectives of people, or organisations, are increasingly able to network and amplify ideas to affect public opinion using digital media; and this can be done strategically to influence the processes and outcomes of private and public resource allocation. Rhodes' (1997) notion of governance was labelled "cybernetic", foretelling an explosion of communication- and automatic control systems. This is the background to my understanding of governance, which is one whereby we can no longer pinpoint a single centre of institutional power – and thus we can no longer focus a critical analysis of discourse, policy, and action on a single centre of accountability and responsibility.

Kooiman (1999) likewise advanced a systems thinking approach, distinguishing the process of purposeful intervention, such as a new policy (governing), from the systemic effect (governance), or outcome, which emanates from an indeterminate, interactive, and interdependent social-political dispensation. Kooiman's (1999) emphasis on the fluid institutional arrangements which indeterminately shape-shift to address societal problems, or to create certain opportunities, is particularly useful here. It is useful because the diversity and complexity which characterises

contemporary governance implies an unprecedented rapidity and frequency of institutional re-arrangement, or adaptive networks, which determines how resources are allocated and how behaviours are controlled or co-ordinated. But, whilst these understandings are useful for the purposes of my research, there is a problem. That is, a systemic notion of governance systems as networks suggests that traditional concentrations of power (typically markets and governments) have been diffused to a wider array of institutions. This might satisfy those of us who strive for egalitarian and democratic outcomes, but that is not necessarily warranted. This is where issues of economic inequity (Piketty, 2015) and democratic recession (Diamond, 2015) come into play.

A third societal challenge focuses on the more explicit sphere of environmental governance theory that is in question here: environmental degradation (Wunderling et al., 2022). This challenge is interconnected with economic inequity and democratic recession (Fraser, 2021), and it is only when we think of these together that the urgency and significance of potential solutions emerge. In Sections 2.1.1 and 2.1.2, I critically analysed two conceptual solutions that are considered in precisely this context. Before elucidating environmental governance theory in particular, it is important to note the shortcomings of the specific understanding of governance I adopt for my research. As mentioned above, the interpretation that decentralised governance systems embody an egalitarian, democratic re-distribution of power is not necessarily accurate. And, as both Rhodes (1997) and Kooiman (1999) pointed out, there are unresolved questions as to who is responsible if we assume that markets and governments have lost their dominant roles in ultimately determining how resources diffuse and what social-environmental outcomes result from such control and coordination of institutions. This is where the transdisciplinary analytical-conceptual framework of my research as well as my ideational understanding of "power *in* ideas" come in, *i.e.*, when I consider my systems thinking analytical framing as balanced by an analytical focus on the empirical context of interactions between research and government policy. Scholars must, in other words, be reflexive about the development of governance theory (Kooiman, 1999).

One way to secure reflexivity and address societal challenges is the inclusion of non-academic ideas and maintaining some focus on the impact that research findings might have on government policy, and on governance systems as institutional networks circulating ideational power. At the same time, whilst addressing societal challenges, the ever-changing networks and the discourses against which their arrangements are evaluated and justified must be open to critique. This is especially relevant because these networks may lack accountability (Rhodes, 1997), and because alterity may be restricted through the control and coordination of effective governance discourse.

Turning specifically now from governance to environmental governance, Partelow et al. (2020) helpfully trace its development over time. This theory has, as with governance theory, advanced

from centralised toward relational and interactive understandings of control (most notably, polycentrism (Ostrom, 1961), collective action (Olson, 1965), and network governance (Rhodes, 1988); see Partelow et al., 2020). Further, nascent critical sociological scholarship is interested in how particular discourses of and in environmental governance systems create and re-create social reality (most notably, governmentality; Foucault, 1980; Bevir, 2010) (Partelow et al., 2020). And, foregrounding the theme of dynamicity in addition to the themes of diversity and complexity associated with the notion of governance systems as mercurial networks (Rhodes, 1997; Kooiman, 1999), the omnipresence of change has entered environmental governance scholarship. This focus on dynamicity and change is, for example, noticeable in adaptive governance and evolutionary governance theory (Partelow et al., 2020). Lastly, and crucially for the purposes of my research, (ideational) power relations expressed through discourse have also entered the domain of environmental governance theory (Partelow et al., 2020). The trend outlined here suggests an overall development of this literature toward "*collaborative knowledge production, systems thinking, and interdisciplinarity*" (Partelow et al., 2020, p. 10). But if we are to think of knowledge production as an activity that is inextricably interconnected with the assertion of power – in the context of urgent and significant social-environmental challenges which we must address through mercurial networks – this trend in environmental governance theory warrants critique.

To balance and qualify this critique, some relevant and recent features and trends of the theory in question must first be given credit. Cowell et al. (2020) explicitly relate the context of perpetual flux (especially in terms of territoriality or geopolitical turbulence) with environmental governance as a concept. Their study is particularly relevant here because i) waste governance is used as an illustrative, empirical example of environmental governance theory in general, and ii) insights from critical sociological scholarship are used to problematise waste governance discourse (Boltanski & Thevenot, 2006). Further, Cowell et al.'s (2020) work is directly relevant because it critically analyses the polemical development of CE discourse. They argue that there is a neglect of the pluralism which already characterises contemporary environmental governance, and that it is this neglect which tends to precipitate in reductive sociological scholarship on related power relations (Cowell et al., 2020). This argument has merit and responds to an important gap in the literature: a lack of "*examination of legitimating logics for policy change*", which typify different value judgements (Boltanski & Thevenot, 2006; O'Neill et al., 2018; Cowell et al., 2020, p. 3). Whilst Cowell et al. (2020) reject the starting assumption of domination in existing arrangements, the application of Boltanski & Thevenot's (2006) "orders of worth" in an analysis of CE discourse in post-Brexit UK produced results which suggest that "market" logics are most commonly and effectively employed when calling for the maintenance of regulatory harmony between the EU and the UK. Interestingly, however, Cowell et al. (2020) also present data

suggesting that "civic" logics are prominent in CE discourse, asserting the important role of established institutions as well as third sector institutions and the intrinsic social-ecological value judgements that they tend to represent. Still, most participants in their interviews articulated an unambiguous hierarchy wherein the intersection of market and civic logics prevail over ecological logics (Cowell et al., 2020). In sum, Cowell et al. (2020) produce a valuable position which highlights the diverse and complex nature of contemporary waste governance systems and illustrate the important role of interpretive agency accompanying the turbulence or dynamicity of perpetual processes of institutionalisation.

It is clearly important and valuable to investigate the semantic tools with which agents mobilise justifications and criticisms of particular courses of action in environmental governance systems because, as has been suggested up to this point, the stakes are high and information is abundant. That is, the societal challenges we face are existential in their scale and implications, whilst the means by which specific solutions to these challenges can be authoritatively diffused are myriad. Hence, a critical approach to the study of urban waste governance is essential. And, hence, a one-dimensional methodology might be insufficient to facilitate such a cautious or critical analysis.

In a multi-methodological manner then, Koch et al. (2021) combine an empirical qualitative study with social network analysis to better understand the role of both narratives and social structure in environmental governance. In this insightful elucidation of the role of agency *and* structure in environmental governance systems and of change in their institutional arrangements, Koch et al. (2021) highlight local context. Instructive for the design of my research, their study focusses on the creation and re-creation of environmental governance "entities", and the constitution of entity-specific capacities to achieve their objectives, as a function of communicative and interactive social relations (Bodin et al., 2019; Koch et al., 2021). Employing the synergistic assumption underpinning collective action theory, Koch et al. (2021) define environmental governance entities as both formal collaborative organisations and informal groupings like temporary-topical social movements. They analyse the role of narration in the maintenance and transformation of social relational structures that hold governance entities together. Ultimately, the authors produce an ontological and explanatory conceptual model which simultaneously applies systems thinking and context-sensitivity (Koch et al., 2021). But, despite helpfully close similarities, the research design of my thesis here differs significantly from that of Koch et al. (2021).

First, I reject the assumption that narration mainly catalyses alternative imaginaries of the future (Veland, 2018). This is because it is important to recognise that narration can also catalyse the maintenance of undesirable status quos – especially in this age of rapid digital communications – and critical scholarship focused on this danger is necessary to prevent it from happening. Second,

I also reject assumptions of "bottom-up" individual-to-collective constructions of environmental governance capacity asserted by Koch et al. (2021), underpinned by mutual trust and effective collaboration (Ostrom, 2000). This second deviation from the cited literature is necessary to analytically accommodate the importance of situating environmental governance (as it is exercised in reality) within the real context of competitive capitalism – a crucially important factor which is dealt with further in Section 2.2.2. Third, and this relates to my first point of difference, rather than narrative congruence (the tendency for entities to orient their discourse to align more closely with that of others who are powerful), it is *discursive divergence* (and the critique it implies) which I consider to be effectively emancipatory. Further, Koch et al. (2021) suggest that brokers, who can be thought of as gatekeepers which connect disparate cliques, are important facilitators of collaborative action through integration. But brokers can also use their influential positions to exploit resource flows (Gorris et al., 2019). In closing, Koch et al. (2021, p. 9) acknowledge that the global consolidation of environmental governance fails to deliver "*societal transformations toward sustainability at the local and regional level*". It is partly this challenging conclusion which informs my transdisciplinary analytical-conceptual framework and my interdisciplinary theoretical framing in this research, as well as my mixed method methodology.

In order to explain why I combine systems thinking (analytical frame) and sensitivity to context in the interaction between research and government policy (conceptual frame) with an attempt to combine environmental governance and critical institutionalism (theoretical frame), Beunen & Patterson's (2019) analysis of institutional change in environmental governance is a good basis. Their analysis may also be useful to understand why *discursive consolidation* fails to deliver desired outcomes. Firstly, Beunen & Patterson (2019, p. 13) identify a gap in the literature that is relevant to my research design: there is a "*tremendous need and untapped potential to draw on these wider traditions of institutional scholarship within environmental governance*". There is an opportunity to combine analyses of the structural and agentive aspects of environmental governance systems. Gravitating toward a pragmatic account of institutional change, Beunen & Patterson (2019) argue that we should simultaneously consider why and how institutional arrangements do *not* change. Typically, this can be because incumbents want to maintain their dominance and might advance a variety of justifications, through a variety of means, to that end (Mahoney, 2000; Pierson, 2000). This useful consideration of agency and its maintenance of existing structures is juxtaposed with the often unintentional causes of institutional change in environmental governance, like crisis events (Douglas, 2016). Further, Mahoney & Thelen (2010) argue that there can also be more subtle and gradual forms of institutional change which hinge on the inherent ambiguity of rules and policies. Importantly, narrative analysis alone may be insufficient for critical understandings of why certain institutional arrangements change or persist

over time (Van Assche et al., 2012). Hence, Beunen & Patterson (2019) set out to advance the wide notion of "institutional work" (Lawrence et al., 2009), describing the purposeful maintenance, creation, or disruption of institutional frameworks.

Institutional change can be non-purposive, resulting from structural determinants rather than agentive interventions (Bourdieu, 1977). Or it can be hermeneutical – since the meaning of extant institutions can organically and randomly, or stochastically, change over time (Ellickson, 1991). This is an important point: it alludes to the parallel possibility that "*the degree of ambiguity and scope for interpretation/contestation*" is related to the discursive power that certain agents wield, and therewith support or actively resist change (Mahoney & Thelen, 2010; Beunen & Patterson, 2019, p. 17). On a simpler note, Beunen & Patterson (2019) justify their critique of institutional work based on the need to make it more strategic and sensitive to context and to intense political contestation when it is applied to environmental governance. This imperative of accounting for a stochastic, indeterminate process of perpetual institutionalisation motivates my research design to go beyond discourse/narrative analysis and social network analysis (Koch et al., 2021). And, further, the need to sensitise the application of institutionalism scholarship to context and politics in environmental governance systems motivates my mixed method methodology. A mixture which includes a qualitative analysis with social network analysis and agent-based modelling is a useful approach to my research aim: within a combined analysis of agentive and structural drivers of institutional arrangements in environmental governance, social network analysis and qualitative analysis can account for complexity and diversity. However, they are not sufficient to improve our understanding of the dynamicity of involved processes. To account for temporality and the ever-presence of stochastic change, I select agent based modelling as the third dimension of my mixed method methodology (this is detailed in Chapter 3). Furthermore, the variability and relevance of place-specific context motivates my choice of multiple research sites.

Bricolage, or the eclectic assimilation of extant institutional rules and structures, is also a useful concept akin to institutional work – since it invites us to consider organic, diverse, and bottom-up processes of institutional change (Van Assche, Beunen & Duineveld, 2014). But my research design is such that neither institutional work (as adapted by Beunen & Patterson (2019)) nor the idea of bricolage is completely suitable here. These concepts are unsuitable for the following reasons. First, Beunen & Patterson (2019) urge us to go beyond the *process* of institutional change by analytically including the *outcomes* or actual effects of change. Therefore, research questions in my research design (Section 1.8) are formulated to guide an investigation of composition, structure, and their interplay with the institutionalisation of specific instantiations of ideational power. Second, an inclusion of outcomes in our analyses should not preclude sufficient focus on

the *temporality* of institutional change in the context of highly dynamic or volatile governance *networks* (Beunen & Patterson, 2019). This is important because, given the context of rapid technological development and concomitant adaptations of commodification, the actual effects of institutional change are always tentative. Third, the communicative and political character of *environmental* governance should be foregrounded to counteract the anti-political tone of discourses which incorporate the specific instantiations of ideational power chosen for this thesis (Carstensen & Schmidt, 2016; Larsson, 2018; Beunen & Patterson, 2019). Fourth, a more *systemic* approach which does not inflate the relevance of individual action and its intentionality (Beunen & Patterson, 2019) may illuminate the emergent and organic growth of heterogeneous environmental governance networks. And, lastly, to deepen the interdisciplinary combination of institutional- and environmental governance scholarship whilst attending to the *contextual* nature of institutional change in this research design (Beunen & Patterson, 2019), a significantly more *critical* approach is adopted with regards to the desirability of thinking, regulation, and action which effectively maintain extant institutional structures or compositions *in specific places*. However, context includes global societal elements (*e.g.*, capitalism and its social-environmental effects) and regional societal elements (*e.g.*, party political balances of power or fiscal relations). To elucidate this distinguishing approach to my aforementioned interdisciplinary undertaking, I now turn to a specification of the institutional*ism* scholarship I selected for my research design; and I specify, in tandem, the broader context which motivates this selection and my way forward.

2.2.2 Critical institutionalism

In this section, I start by foregrounding the importance of the broad context of capitalism as the underlying social system underpinning my research problem. I do this with reference to critical sociological work which, I argue, contributes to an interdisciplinary approach to understanding the commodification of waste – including concepts with political traction which interact with it. Then, I proceed to critically review cutting edge literature in the wide and growing field of institutionalism. This ultimately leads to a focused and in-depth review of critical institutionalism, which raises questions about how processes and outcomes of institutionalisation are influenced. Lastly, the crucial issue of emancipation – or the effective resistance of domination – in urban waste governance systems emerges and this warrants an unconventional methodological strategy. Hence, in the next section, I summarise insights gained from the selected critical institutionalism and environmental governance literature to inform the methodology which follows in Chapter 3.

Capitalism is understood here as the systemic foundation of commodification – of waste, but also of an ever-wider array of phenomena including the commercial proliferation of information and communication technologies. It is important to reiterate that the notion of capitalism I employ permeates the foundational social and economic substrate upon and through which processes of

institutional change in urban waste governance systems are catalysed. This notion of capitalism is intentionally broad, encompassing the wide spectrum of economic and political phenomena surrounding the governance of environmental issues, such as waste in cities. It is through such a globalised logic of commodification, an evolving and adaptive logic underpinned by a perpetual, pervasive drive toward expansion and the attribution of monetary value to an ever-wider array of phenomena (Boltanski & Esquerre, 2017; Susen, 2018), that the ideational power conferred by institutional alignment with capitalist ideas manifests and proliferates. Still, there are "*historical*" (Boltanski & Esquerre, 2017, p. 13) and/or "*spatiotemporal*" (Susen, 2018, p. 9) differences, across time and space, in how capitalism manifests and proliferates (Fraser & Jaeggi, 2018). As with the concept of governance I elucidated in the previous section, it is important to note the adaptive nature, or dynamicity, of capitalism because this is a key attribute. This means that urban waste governance – which I focus on in this study – and its permeation with capitalist ideas is expected to manifest differently in different contexts. This is a key attribute in the context of my research objectives because it partly motivates a comparative empirical study as well as a mixed method methodology which includes agent based modelling (see Section 3.5). A comparative and multi-method research design allows for better understanding of what elements in the transition towards (in)equitable waste governance systems might be universal. This also partly motivates my hypothesis that the ideational power in certain ideas restricts processes of institutional change in urban waste governance to one metamorphic outcome, *i.e.*, commodification. Whether and how global crises can be addressed in an emancipatory way remains uncertain if we fail to critique and meaningfully alter the logics causing those crises (Boltanski & Fraser, 2021). And, whilst such a comment might seem to protrude the boundaries of this thesis, it is important to situate research about specific phenomena like urban waste governance in wider sociological contexts or systems.

Ultimately, and more directly, my object of critique here is the commodification of waste in cities. Before detailing my reasons for this selection and its substantive content, it is necessary to repeat that I approach this interdisciplinary theoretical frame through a transdisciplinary analytical-conceptual frame (systems thinking (analytical), and context in the interaction between research and policy (conceptual)) (Figure 1). This is important to note because, firstly, a systems thinking analytical frame assists with a critique of institutional change in urban waste governance systems as complex networks. The discursive mobilisation of ideational power, which I elucidate below, warrants an appreciation of multiple perspectives; and processes and outcomes of institutional change in environmental governance must be considered as emergent and systemic phenomena rather than products of intentional and individualised causal patterns (Beunen & Patterson, 2019). Secondly, context in the interaction between research and government policy assists with overcoming the ineffectiveness of critiques of capitalism today (Boltanski & Fraser, 2021). My

conceptual framework assists in this way by ingraining the broad context of contemporary capitalism as well as the place-specific context of multiple research sites into a research design which itself attempts to produce analysis that matters for, and encompasses, government policy. Lastly, this is cemented by incorporating a critical, reflexive analysis of qualitative data indicating historical and current factors affecting waste governance in distinct and different urban contexts.

Without pre-empting the detailed account of how exactly these frameworks are to be applied, which follows in Chapter 3, suffice it to say, for now, that unconventional forms of discourse are used as the starting point in a purposefully mixed method methodology which aims to tie together all the above.

In order to justify the application of critical institutionalism, I have so far focused on its "critical" dimension, but I have not yet done so regarding its more generic "institutional" aspect. Below I elucidate why better understanding the commodification of waste – including ideas with political traction – which is shaping and shaped by institutionalised urban waste governance is my aim. My interpretation of the term "institutions" is quite specific in the case of this research design, and it departs from Boltanski's (2011: p. 79) acknowledgement that there is a particularly cross-cutting interpretation which simultaneously encompasses regulatory, semantic, and material meanings. Usually, a binary approach is taken to the term with one (colloquial) side stressing the material dimension, as in organisations with buildings, people, and bank accounts, and the other (academic) side stressing the regulatory dimension, as in formal rules or informal conventions of behaviour. Elaborating on the social-systemic understanding of contemporary capitalism, Boltanski & Fraser (2021) argue further that a third – *semantic* – dimension of institutions carries emancipatory potential despite the general crises which the domination of this dimension has historically given us (Searle, 1997). The point being that, as with any powerful tool, this semantic dimension can be used to creative as well as destructive ends. But, to elaborate on this semantic meaning and connect it clearly to the regulatory and material meanings, it comprises the ideational power of institutions to make sense of events and make value judgements. By extension, *institutionalisation* in environmental governance involves the entrenchment of authoritative regulation, the popularisation of semantic norms, and behavioural conventions. These meanings cannot and should not be thought of separately *if* we intend to produce critique affecting institutional change that can transcend the boundaries between concepts, rules, and actions.

Before I detail exactly how and why critical institutionalism enables such transcendence, I briefly note other key institutionalisms and their core tenets as described in the academic literature to justify my selection of critical institutionalism in particular. First, and this is helpful to understand the constitutive consequences of ideational power, constructivist institutionalism emphasises

social construction (Hay, 2016). In essence, for Hay (2016), this form of institutionalism is focused on unpacking the configurative role of institutions which ideationally demarcate the spectrum of social possibility. Herein lies a useful parallel with the understanding of institutions I advance in this study, which is the notion that there is a functional interlinkage between the regulatory, semantic, and material dimensions of the term. This is quite distinct as far as institutionalism goes because an emphasis on ideas and language *politicises* agents navigating coexisting, incommensurable social realities (Hay, 2016). Yet, constructivist institutionalism's dismissal of institutional structures and agents, as well as their consequences or effects, as relatively unreal abstractions (vs procedural and "*praxiological*" reality) puts it at odds with the assumptions underpinning my research (Hay, 2016, p. 526). This is an important point of difference which, I argue, relates to a *dematerialisation* of capitalist logic (Boltanski & Esquerre, 2017; Boltanski & Fraser, 2021), as well as to the digitised commodification of social data – with real consequences for democracy and equity (Harari, 2016; Ulbricht, 2020). I accept as real the environmental governance structures and agents through which the above mentioned capitalist logic diffuses in cities, and the social-environmental implications of this phenomenon. Further, my research differs in that it does not aim to trace *the process* of institutional change to isolate and explain a certain pathway of causality (Trampusch & Palier, 2016). Rather, I ambitiously set out to critically analyse key processes *and* outcomes of institutional change. That is, I do not problematise or question the construal of problems or crises (Hay, 2016). I assume that a general crisis exists and critique assumptions that waste commodification is the solution (Fraser, 2021).

Advancing from the view that ideas matter in the politicised process of institutional change, Carstensen & Schmidt (2016) helpfully refine discursive institutionalism by specifying different types of ideational power. But, before narrowing down the appropriate type of ideational power for the purposes of my research, a brief account of discursive institutionalism's gist is in order. The basic principle underpinning this variety of institutionalism is that "*symbolic and normative resources*" significantly co-constitute the assertion and exercise of power (Barnett & Duval, 2005, p. 50). Splintering somewhat from the main body of scholarship following the work of Foucault (1980), Carstensen & Schmidt (2016) distinguish discursive institutionalism as a theory which embraces the capability of agents to reflexively critique their own ideas (Carstensen, 2011), and collectively transform the institutional structures currently demarcating action and thought (Schmidt, 2008). This view is at the heart of the definition of power in constructivist institutionalism (Hay, 2002), illustrating the substantive parallels and fine line of separation between these academic categories. Not unlike Beunen & Patterson's (2019) take on "institutional work", discursive institutionalist scholars give credence to both structural and agentive determinants of behavioural potentiality. Within discursive institutionalism, power is

conceptualised as the production of "*particular kinds of effects*" (Barnett & Duval, 2005, p. 42) with regards to "*the capacities of actors to determine the conditions of their existence*" (Carstensen & Schmidt, 2016, p. 322). My research aligns with this notion of power. However, I assign primacy to structural determinants of behaviour and pay special attention to restricted alterity stemming from the operation of power *in* ideas (Carstensen & Schmidt, 2016). That is, applying the useful analytical distinction provided by Carstensen & Schmidt (2016), the focus here is on the underlying institutional structures that constitute the pool of ideational resources from which and relative to which agents effectively seek to control their conditions of existence. The overarching form of power in ideas at issue in my research design is a capitalist social system, which I argue is so omnipresent in our everyday that it is hard to imagine life outside this context.

This raises the question of structural rigidity versus agentive dynamicity. As I stated before, urban environmental governance systems operate in the context of diversity, complexity, and dynamicity. And, unlike Foucault's (2000) emphasis on the rigidity or fixedness of institutional structures, Carstensen & Schmidt (2016) instead point to a dynamic and constant process of conscious or unconscious re-construction of the adaptive institutional edifice of ideas. Yet, the adaptation or adjustment of existing realities begs questions about the desirability of status quos. Specifically focused on such questions, Boltanski (2011) assigns great value to the act of critique which can draw from empirical data to contradict the structuring logic of power in certain ideas. But when it comes to capitalism in its wide variety of forms and functions in modern society, contemporary critique has failed to effect change (Boltanski & Fraser, 2021). This may be because the power in its ideas is so immense and commonplace (especially in the West and postcolonial territories where Western societal models still dominate, the crystallisation of capitalist logics in institutionalised social structures has arguably reached a resiliently advanced stage), that imagining anything fundamentally different is virtually impossible (Carstensen & Schmidt, 2016). Or it may be because many critical thinkers are incentivised to ally with institutionalised power in capitalist society, and thus representations of alterity historically articulated through social movements is disintermediated or neutralised – at least to some extent (Boltanski & Fraser, 2021). In any case, Carstensen & Schmidt (2016, p. 333) admit that "*more fine-grained empirical analyses*" are necessary, as is the identification and critique of agents or institutions which have a big impact on what is problematised *and* how to solve that. Contestation is increasingly nuanced.

In contrast to the above, some scholars doubt that we can know of all such agents or, moreover, doubt that it is possible to accurately assign a hierarchy of relevance or impact to agents or institutions (Larsson, 2018). This is the post-structural variety of institutionalism. This variety and its scholars emphasise an ever-present space to contest meaning, as well as the ever-changing

constellation of institutional heterogeneity (including ideas, rules, and actions) in a given situational context (Larsson, 2018). Advancing Foucault's (1972) understanding of discourse as encompassing more than language or communication, Larsson (2018: p. 329) suggests that discourse includes all forms of "*powerful truth claims*". This broadened notion of discourse is applicable to the contemporary context of rapidly evolving information and communication technologies; thus, it may even include algorithms (Harari, 2016). Post-structural institutionalism resonates with governance systems, defined as socio-cybernetic networks of interactive and interdependent, but diverse and complex, agents (Rhodes, 1997; Kooiman, 1999). The conceptual similarity between governance and post-structural institutionalism is the holistic or systemic view of institutional change which cannot be reduced to individualised chains of cause and effect. Further, post-structural scholars have critiqued discursive institutionalism's omission of power asymmetries and thus identified the need to apply the analytical construct of power in ideas to the "*here and now*" of contemporary institutional afflictions (Larsson, 2018, p. 339). For example, the "post-structural" rejection of structural rigidity makes it difficult to effectively inform analysis and critique of how discursive hegemony evolves; thus, Larsson (2018) combines this with an "institutionalist" framing which suggests that discursive dominance of any given idea can be measured by assessing its relative degree of institutionalisation. My research design echoes this notion by analysing the institutionalisation of the CE and FEW nexus concepts in different cities.

Nonetheless, post-structural institutionalism lacks something I consider crucial for my research aim: a substantive analytical appreciation of the emancipatory and developmental role of critique. Boltanski (2011) elucidates this role by detailing the recurring sociological cycle of institutional stability and critical destabilisation – two states that are always in flux. Importantly, institutions are understood to have an inherent element of "violence", purposefully enforcing conformity and generality in contexts of diversity and complexity, thus establishing and maintaining uniformity of thought, rule, and act (Boltanski, 2011). But there is a crucial counter-balance which drives institutional change: alternative views of reality which directly contradict the institutionally produced "truth" at any given time and place. With this understanding in mind, we can conceive of a refined process of institutional change – or institutionalisation – dependent on critique; a process whose possibility varies in its forms and magnitude across space and time (spatially, historically, etc.) (Boltanski, 2011). This relative degree of the space or possibility for effective critique can be used as an indicator of the relative degree of emancipatory potential from domination, which unchallenged institutions inherently imply (Boltanksi, 2011). In terms of outcomes, the evaluative learning necessary to secure accountability and authenticity in governance networks is ingrained in such a cycle of critique (Rhodes, 1997; Kooiman, 1999).

Specifically, critique fulfils this purpose by testing the link between discourse and empirical experience and assigning responsibility for the frailty or sturdiness of that link to representatives of those powerful institutions which hold the current monopoly over the "production of truth". It is this fundamental point which leads me to decline the "commons" emphasis in some scholarship furthering critical institutionalism: I reject the dissociated analytical deployment of "discourse", on the one hand, and "political economy" and "rules and norms", on the other hand (Whaley, 2018). Discourse, political economy, and rules and norms are not merely inter-related phenomena but are mutually constitutive in this information age wherein discourse underpins an inextricably interconnected politics-economics, the capitalist society (Fraser & Jaeggi, 2018). Furthermore, and to bring this into more direct and explicit relation with the central problem motivating my research aim and objectives, the fundamental importance of the possibility and process of effective critique (as above) for emancipatory institutional change in urban waste governance systems is the reason why, in my opinion, *discursive consolidation* - a negative postulation of the more affirmative "bricolage" propping up collective action - is a challenge that needs to be overcome. Instantiations of critique, which by their very nature draw from worldly and hence situated contexts, are best understood with reference to specific exceptions to the "general rule" (Boltanski, 2011). And, as noted above, such exceptions and the opportunities for agents to enunciate them effectively manifest themselves differently in different places at different times. That is why several distinct research sites are incorporated into this study, and why a mixed methods approach is taken. Without multifaceted approaches, the heterogeneity of the phenomena in question cannot be meaningfully and critically analysed within a systems thinking framework.

In order to conclude this chapter, I specify the strand of critical institutionalism I chose for my research – with a certain adjustment informed by critical sociology. I do so with reference to the transdisciplinary analytical-conceptual framework I selected for this research, already alluding to my selected research methodology. To elaborate on the final point of the previous paragraph, critical institutionalism – in whatever form – faces the following key challenges which scholars ought to address: the i) complex-embeddedness of institutions, ii) policy relevance and effecting change, iii) an exclusive academic tone of the theory bypassing investigation of the ordinary, informal, or every-day, and iv) foregrounding power and meaning in practice (Whaley, 2018). I address these challenges as follows. First, I address the complex-embeddedness of institutions through a conceptual framework which explicitly focuses on context in the interaction between research and government policy. This also addresses the second challenge by investigating policy relevance and trying to assess whether unique polices effect change in specific places. Second, I build an element of empirical data collection into a mixed method methodology including social network analysis, qualitative (empirical) analysis, as well as agent based modelling – with strong

links between these (Figure 6). Third, different research sites offer the opportunity to conduct a comparative analysis of the relevant complex-embeddedness of institutions. Lastly, in a transdisciplinary spirit (which underpins my systems thinking analytical framework), a multiplicity of perspectives and themes are invited to feed into my empirical data collection process (Section 3.4); that is, a multiplicity that purposefully invites non-academic perspectives. Whilst this is not a novelty, I consider it to be a contribution in relation to critical institutionalism literature and its self-identified gaps (especially as it is applied to urban waste governance here).

The final challenge, foregrounding power and meaning in practice, is addressed by my selection of critical institutionalism and by combining it, in an interdisciplinary spirit, with environmental governance and, albeit less extensively, with critical sociology. For critical institutionalism, my main point of departure is Vira (1997), and this relates to my critique of the CE and FEW nexus concepts in Sections 2.1.1 and 2.1.2. That is, Vira (1997) amplified founding works such as that of Arrow (1951) by problematising then popular quantitative analyses of institutional performance. Regarding waste in cities, examples of analogous measurements of success would be purely monetary or material quantifications of economic and/or industrial optimisation or efficiency. But, specifically, Vira (1997) argued that such analyses are necessarily laden with value judgements; and that such value judgements and the existing configuration of institutions against which they can be meaningfully and effectively enunciated are vital – and should therefore be made explicit. In particular, the existing configurations of institutions probably comprise inequalities of power (Vira, 1997). "*The normative goal of public policy should be to promote outcomes deemed to be socially desirable*", but the object of social desire is a complex moving target (Vira, 1997, p. 762). This is a key point. To more clearly relate environmental governance and the ideas selected for my research with critical institutional scholarship, the "*scientific air of neutrality to policy propositions about institutions*" which "*essentially normative*" terms such as CE or FEW nexus convey is problematic (Vira (1997) paraphrasing Bromley (1989, pp. 57-79)).

Elucidating contemporary developments in global capitalism through a critical sociological lens, Boltanski & Esquerre (2017) argue that new forms of capital accumulation are emerging. Their argument, that processes of valorisation are becoming increasingly diversified and creative, is strong. It is driven by discursively modified objects of social desire, or normative instantiations, which now draw more from the past than ever before (Boltanski & Esquerre, 2017; Susen 2018). What this implies, to my mind, is that processes of commodification are becoming increasingly fundamental to what it means to be human: more intertwined with the sociality that defines us.

2.2.3 Summary

Contrary to early critical institutional scholarship, which argued that, for example, "*institutional arrangements*" … "*that are devised to reduce the wastes of the common pool simultaneously define a distribution of wealth and political power*" (Vira (1997, p. 771) quoting Libecap (1989, p. 116)), and that contestations of inequitable distributions of wealth and power could be quelled through whatever form of compensation for losers, I concur with Boltanski & Fraser (2021) that contestation is essential for effective emancipatory processes of institutional change. What is at issue, for me, is the continuation, indeed the evolution, of a logic of commodification which has historically constituted the root cause of deep economic inequalities (Piketty, 2015), environmental degradation (Wunderling et al., 2022), and democratic recession (Diamond, 2015). It is this continuation or evolution which, I postulate, is typified by the commodification of waste in cities. And, if this is the case, what we are dealing with is a systemic adaptation to the aforementioned crises – an authoritative re-interpretation of these crises as opportunities for the root causes which created them to grow deeper by restricting our scope of ideation for solutions to self-same logics. Again, in order to fully appreciate this problem, we must understand the aforementioned crises as intertwined and pragmatically inseparable (Fraser, 2021). And, in order to appreciate this problem, we must understand contemporary global capitalism as a profoundly adaptable and hermeneutic social system (Boltanksi & Esquerre, 2017; Fraser & Jaeggi, 2018; Boltanski & Fraser, 2021). This hermeneutic element, combined with the technologically mediated mobility of information, nudges this logic from an economic to a socio-cultural sphere.

Thus, in urban waste governance, the discursive convergence of environmental care and logics of commodification inherent in contemporary capitalism might nullify questions of equity. If we assume that the CE and FEW nexus concepts are necessarily laden with value judgements insofar as they are catalysts of a certain kind of institutionalisation in urban waste governance systems or networks, critical institutionalism begs us to consider who benefits and who suffers loss (Vira, 1997; Lok, 2018). Further, if we assume inequalities of ideational power in institutional structures are so exerted, the emancipatory value of critique becomes essential in said consideration (Lok, 2018; Boltanski & Fraser, 2021). Critique of institutionalised power in ideas may thus catalyse imaginaries of alterity, and it may cut deep enough to enable the suspension of dominant material-economic values. The use of the term "suspension" rather than something like "replacement" is purposeful here because the material-economic "common sense" of CE and FEW nexus thinking is not at issue. There are undeniably desirable improvements of efficiency which stem from the application of these concepts, relative to the wastefulness of extant, linear value chains separated by sector-silos. What is at issue, rather, is the notion that the institutionalisation of these ideas can constitute post-capitalism as opposed to a problematic evolution of capitalism as is (Boltanski &

Esquerre, 2017). I consider such an evolution to be problematic because it reinforces an institutionalised "iron cage" of "*rules, norms, and beliefs through which* [we] *define* [ourselves, thus delimiting our own] *basis for unlocking new ways of being and acting*" (Lok, 2018, p. 339).

In the context of the relational and interdependent nature of urban waste governance systems, the "*widespread commodification of relations … poses profound civilisational challenges*" (Boltanski & Esquerre, 2017; Susen, 2018, p. 48). As I have argued up to this point, the CE and FEW nexus concepts propel a relational commodification of waste, and this is a challenge. In the highly complex, diverse, and dynamic context of contemporary cities, this challenge is spatio-temporally contingent. Hence, disciplinary and methodological multiplicity is incumbent on my research which critically analyses key processes and outcomes of institutional change in urban environmental governance systems, using comparative waste commodification as empirical cases. The distinctiveness of cities included in my research attests to my alignment with the "pragmatic structuralism" of Boltanski & Esquerre (2017). That is, I concur that analytically "*combining, cross-fertilising, and integrating macro-sociological structuralism and micro-sociological pragmatism*" (Susen, 2018, p. 54) is vitally important since "*(e)xperiences and structures are anchored within the "scheme of existence"*" (Boltanski & Esquerre, 2017, p. 358).

In closing, my theoretical framework informs a critical analysis of multifaceted data emanating from urban environmental governance systems wherein waste is being commodified. In Chapter 3, I detail the overall methodological framework and the exact procedures which operationalise my research design presented in Chapter 1 with reference to this theoretical framing (Chapter 2).

3 Research Methodology

In this chapter, I first present an overview of the overall research methodology as advocated and supported by the theoretical framework presented in Chapter 2. Then, I justify the selection of an urban scale for this analysis, and I briefly describe the specific cities providing comparative empirical context. Next, I introduce and describe three integrated methods used to collect data. I conclude with the procedures and justification for their mixed application (and data triangulation).

Specifically, in Section 3.1, I introduce the overall methodological framework and its structure. Then, in Section 3.2, I identify the scale of analysis selected for this research with justifications drawn from the literature reviewed in Chapter 2. This includes an identification and elaboration of the specific research sites chosen for this comparative study – and a justification for that. In Section 3.3, social network analysis is introduced, and the procedures followed in the application of this method are explained. This includes the sample selection for the overall methodology's data collection process. In Section 3.4, I introduce the qualitative analysis method, which advances from the social network analysis method. Therein, I explain the process used to analyse interview data, and I describe how said analysis influenced my overall research design. And, in Section 3.5, I introduce the agent based modelling method and describe its design in this thesis, with theoretical and empirical justifications following the previous two methods. Lastly, in Section 3.6, I conclude with an account of how and why the respective methods are integrated.

3.1 Overall methodology & structure

Simultaneously analysing the role of ideational power and that of social structures in the process of institutional change, and its outcomes, in urban waste governance systems – whilst employing a broad conception of institutions encompassing both regulatory and semantic dimensions (as well as material implications) – requires a mixed method approach. In practical terms, this means that such a multifaceted approach must be designed to effectively integrate individual statements, or instantiations of discourse, as well as aggregate social relational structures, or "snapshots" of institutional governance structures that are constituted, maintained, or changed by such discourse. However, a "snapshot" of one urban waste governance network (singular empirical context) may be inadequate to theorise the process of institutional change and its outcomes with sensitivity to the spatio-temporal contingency of commodification (Boltanksi & Esquerre, 2017; Susen, 2018). Therefore, in accordance with the analytical (systems thinking) and conceptual (context in the interaction between research and government policy) transdisciplinary framings of this research, this methodology must be designed to appraise a multiplicity of perspectives in multiple contexts. Such a design addresses the spatial contingency of the relevant processes and their outcomes, here

hypothesised to mainly entail commodification, but it fails to address their temporal contingency. Therefore, the comparative case design, which facilitates an appreciation of multiple perspectives and contexts, should be extended with a method that extrapolates the aforementioned "snapshots".

In order to situate this overall methodology more explicitly within the relevant literature, there is a need to acknowledge the important role of human agency as it relates to the omnipresence of change in environmental governance (Allouche et al., 2019; Partelow et al., 2020). But there is also a need to acknowledge the reality of regulatory consistency and capitalist incentives for standardisation – which culminates in significant forces actively resisting institutional change (Beunen & Patterson, 2019; Cowell et al., 2020). To understand the outcomes of agentive counteractions pursuing institutional change and structural forces resisting institutional change in contemporary urban waste governance, one must consider both unique regional context *and* the shared / wider context of a contemporary capitalist society propelled and mediated by ubiquitous information and communication technologies (Fraser & Jaeggi, 2018). This latter, wider context is all the more important for a study such as this one since it employs the notion of hegemonic power in ideas (Carstensen & Schmidt, 2016) and problematises it with reference to a general and global crisis of interrelated environmental and social afflictions (Fraser, 2021). Moreover, the pragmatically and scientifically authoritative concepts of a circular economy (CE) and of the food-energy-water (FEW) nexus are here construed as instantiations of the aforementioned notion of hegemonic power in ideas – or discursive consolidation – in urban waste governance. This construal is perhaps juxtaposed to Koch et al. (2021), who present an affirmative analysis of narrative congruence and corollary constructions of relational environmental governance entities.

For the purposes of this methodology, said juxtaposition can be reduced to two main differences. First, I undertake a *critical* analysis of discursive consolidation (as outlined in the previous paragraph) and corollary constructions (or re-constructions) of relational environmental (urban waste) governance *systems*. It is the emancipatory potential of critique in theorising the processes of institutional transformation and reformation which motivates this first difference (Lok, 2019; Boltanski & Fraser, 2021), and this is reflected by my research objectives, questions, and hypotheses. Second, I extend the valuable methodological precedent set by Koch et al. (2021) (involving the combination of qualitative analysis and social network analysis methods) to extrapolate "snapshots" of urban waste governance systems by combining social network analysis and qualitative analysis with agent based modelling. Through this combination of methods, I am able to stochastically represent and simulate unruly, non-linear processes of institutional change, and to investigate their emergent or structural outcomes (Ellickson, 1991; Mercure et al., 2019). In the subsequent sections, there is a detailed explanation of the specific procedures that are being

followed in the mixed application of these three methods, as well as a description of the process and task of triangulation which aims to integrate their results and to thus achieve my research aim.

3.2 Research scale and sites

The city is the analytical scale selected for this comparative study. In this section, I provide a rationale for this selection and for the selection of a comparative case study approach to further justify the research design presented in Chapter 1. Then, I identify and briefly describe the specific cities selected as empirical contexts for a comparison of institutionalised waste commodification.

3.2.1 Rationale

Following precedent-setting works of Rhodes (1997) and Kooiman (1999) on governance, scale has become pivotal in critical analyses of environmental governance networks (Bulkeley, 2005). In terms of both CE and FEW nexus discourses, some argue that these concepts share "*'resource efficiency of urban systems' at their core*" (Parsa et al. (2021: p. 4) paraphrasing Lehmann (2018)). Illustrating conceptual parallels between the city-scale and governance, scholars trying to foreground inequalities of access which characterise contemporary conditions of life in cities use critical institutionalism to analyse alterity through empirical lenses (Rusca & Cleaver, 2022).

Beyond conceptual parallels between governance and the city-scale, and the centrality of urban systems in the CE and FEW nexus ideas, there are reasons for the selection of Bristol, Cape Town, and Rotterdam in particular. Rhodes (1997) and Kooiman (1999) developed their understandings of governance in the British and Dutch contexts, respectively. Likewise, I started this research in the South African context, and I was resident in Cape Town for the initial phases of this study. This was not only relevant from a pragmatic perspective but also for the fact that it has shaped my positionality and my strong interest in the topic of this thesis (Section 1.6). Following the theme of interdependence in relational social structures characteristic of contemporary urban environmental governance systems, and the simultaneous need to sensitise critical institutional research to empirical context as well as international policy trends, the historical relationship between the UK, The Netherlands, and South Africa matters. These nations are at once distinct and indistinct, each hosting heterogeneous urban contexts and yet all having fundamental similarities in terms of their social structures. The similarities are, for example, unanimous alignment with the capitalist social system as well as British and Dutch rules of law which were replicated in South Africa during the era of international colonial domination. In terms of commodification, Susen (2018) critiqued Boltanski & Esquerre (2017) in that their sociological critique of commodities lacks historical perspective – and a sensitivity to domination in particular. I expand on the reasoning behind my choice to investigate all three cities in the paragraphs below.

In their critical dialogue on capitalism, Fraser & Jaeggi (2018) emphasise the tension between its seemingly contradictory universality and place-specificity, as well as its paradoxical discursive self-differentiation from non-economic spheres (like politics) which it depends on and constitutes. More importantly, whilst I do draw from and build on Fraser & Jaeggi (2018) in that I posit the commodification of waste as a significant self-preserving capitalist manoeuvre to incorporate the limits of natural material productivity and waste absorption, I also draw from and build on their argument that contemporary capitalism is characterised by the following contradiction: its discursive separation of the economic (where capitalism exists and is at issue) from the political (where it does not exist and is not at issue) (Fraser & Jaeggi, 2018). To illustrate the relevance of this point in relation to my selection of research sites, Bristol, Rotterdam, and Cape Town can be understood as being similar in the economic sense and can be understood as different in a political sense. But is this accurate? Fraser & Jaeggi (2018) might disagree by arguing that capitalism is deeply dependent on public power for its longevity, and yet it erodes the relevance of such power. Cowell et al. (2020) similarly argue that "civic" and "market" logics are mobilised *in tandem* when it comes to justifications for internationally standardised waste trade law for European CEs.

More specifically, Bristol, Rotterdam, and Cape Town are all major port cities which served as nodes of connectivity with the outside world, and this gives them a distinct international character. This is reflected in the fact that British and Dutch seafarers arrived at the Cape of Good Hope, an arrival that sparked the colonial development of Cape Town and South Africa as it exists today. Commodities, and the international trade thereof, are intertwined with Bristol, Rotterdam, and Cape Town's urban development, relative wealth, and distinct exposure to powerful global ideas. But there are differences between these cities when we look at each more closely. I do so below. Overall, and in more explicit connection with the hypothesis set out in Section 1.7, understanding waste commodification as an instantiation of capitalism's evolution should not be misinterpreted as a suggestions that (waste) commodification is a globally homogeneous phenomenon. To the contrary, the selection of the city scale and the decision to compare different cities reflects my alignment with Fraser & Jaeggi (2018) in that commodification is *instituted* heterogeneously. Whilst I systematise my analysis of all three cities in question by casting a consistent semantic net for the purpose of comparability, the regulatory and material dimensions of institutionalisation in each city's case may indeed diverge significantly (Boltanski, 2011). Importantly, the degree of i) interconnection and the nature of social structures comprising urban waste governance systems, ii) CE and FEW nexus institutionalisation and associated restrictions of discursive space for alterity, and iii) diversification, stability, and expansion may all be spatio-temporally contingent.

In summary, Rotterdam, Bristol, and Cape Town are simultaneously distinct and indistinct cities. They are anticipated to be distinct in terms of i) the social structures underpinning their waste governance systems, ii) the extent to which power in the CE and FEW nexus ideas is institutionalised to the exclusion of alternative ideas, and iii) the relative degree of their respective waste governance systems' (comprising linked entities embodying the institutionalisation of power in the CE and FEW nexus ideas) diversification, stability, and expansion. However, they are hypothesised to be similar in that each of them hosts permutations of evolving capitalist society and its inherent crises: environmental degradation, economic inequality, and democratic recession. I also hypothesise a trend of institutionalisation culminating in variable waste commodification, disintermediating critique and its effect of deep institutional change (Boltanski & Fraser, 2021). The methodology I set out in this chapter is designed to test the veracity of these hypotheses with consideration of both their spatio-temporal contingency and the possibility that they are incorrect. Indeterminism and stochasticity warrant an abductive-retroductive approach (Section 3.4), and my contingent research problem warrants epistemological pluralism (Tikly, 2015; Stutchbury, 2022). But before I elaborate on said approach and methods which together comprise my methodology, I outline secondary data distinguishing each of the cities, highlighting their historical development, social attributes, and basic trends in their waste governance systems. A more detailed summary of similarities and differences between these cities and their waste governance systems can be found in Table 7, which forms part of the results chapter (Chapter 4).

3.2.2 Site description

3.2.2.1 Cape Town

Cape Town was founded in 1652 by the Dutch East India Company, making it South Africa's original colonial city. It covers 2461 square kilometres of urban development that took place over more than 350 years. The city accommodated a growing (roughly 2.5% per annum) and unequal population of roughly 4.7 million in 2020 (Wilkinson, 2000). Cape Town's metropolitan fringe hosts growing informal settlements that lack access to formal services and amenities like water, sanitation, waste disposal, and electricity (Graham & Ernstson, 2012). Politically, it stands out as the capital of the only province in South Africa that is governed by the main opposition (second most popular political party at the national level): the Democratic Alliance. In terms of spatial planning in its developmental zenith, the metropolis was purposefully designed to entrench socioeconomic separation and inequality under the notorious apartheid regime pre-1994. This design effectively segregated the three main racial groups: "Coloureds" (42.4%), black Africans (38.6%), and whites (15.7%) (Statistics South Africa, 2011). Despite the abolition of legal segregation, the long-term effects of (spatial) inequality persist and can be observed to this day.

The tenability of integrated governance or "co-management" of resources for environmental conservation purposes is a highly contested question due to the complex interplay of the city's apartheid past (including its remaining manifestations of unequally distributed access to food, water, and electricity), poverty, and unequal opportunities (Graham & Ernstson, 2012). Policies that aim to fairly distribute FEW resources and minimise waste (especially water and energy) in the context of socioeconomic inequality and erratic scarcity are known to be challenging in Cape Town (Ding et al., 2021). For example, local government's financial penalties for water use above certain thresholds and price increases across the board (both intended to minimise water use and water wastage), whilst securing free water provision for a substantial constituency of indigent households, have precipitated in highly unequal and unpopular impacts (Ding et al., 2021).

Useful for the purposes of my research, Perez (2021) combined qualitative and quantitative empirical methods to investigate the CE concept's discursive reinforcement of a problematic "status quo" in Cape Town. Fitting squarely within the conceptual framework of my research, Perez (2021) points out that the popularisation of plastic CEs in Cape Town distracts from the fact that preventative legislation has not been forthcoming and structural inequalities in the city might be reproduced if waste commodification is treated as a panacea. This concern is shared by others who highlight the stratification of waste governance in other South African cities. For example, impoverished individuals who collectively do the most significant recycling work ("waste pickers") are being exploited through their exploitative integration with dominant institutions (Samson, 2020). On positionality, which I addressed in terms of my research design in Section 1.6, Perez (2017) found that the marginalisation of waste pickers in Cape Town has reached such levels that covert qualitative data collection techniques were necessary to obtain empirical data despite socio-economic divides between researcher and the researched (waste pickers). Ernstson et al. (2021) point more explicitly to how city-government led programmes and campaigns to reduce waste and dispose of it more responsibly have been frustrated by community pushback, with some challenging the power relations and outcomes of cross-sectoral governance. And, using the severe water crisis that struck Cape Town between 2015 and 2018 as a case study, Millington & Scheba (2021) find that there is a tension between the city's self-set goal to provide certain basic services in an equitable way, on the one hand, and the financial constraints which drive it to the commodification or "*marketisation*" of the same provisions. This is relevant for my study in that regulatory, economic, or technical solutions to environmental problems (like water scarcity) cannot be allowed to worsen socio-structural inequities associated with those problems. Millington & Scheba (2021) effectively illustrate why national and local policy dynamics are irrelevant if compared to palpable social and economic determinants of Cape Town's governance.

3.2.2.2 Bristol

The medieval town of Bristol was incorporated in 1155 and covers an area of 110 square kilometres. In 2020, it accommodated an almost stagnant population of approximately 466 000 people (Bristol Open Data, 2020). Bristol has a national and global reputation for innovation, sustainability initiatives, and "green credentials" (Torrens et al., 2018). Bristol hosts a historic seaport and commercial centre, having been at the centre of several manufacturing and trade developments over time. Politically, as of 2021, Bristolians favour the UK government's official opposition political party, the socially oriented Labour party – which enjoys 50% of total political representation in the city council (Bristol City Council, 2020). While investigating the dynamics of food waste recycling policy in Bristol, Michalec (2020) observed that national policymakers favour voluntary or self-organised initiatives rather than compulsory rules of behaviour – suggesting a self-regulating doctrine (which is characteristic of the nationally ruling Conservative and Unionist Party). Combined with a distinct, cohesive fluidity of identity that allows individuals to move easily between academic, third sector, business, and political institutions associated with urban sustainability agendas, the national political inclination to "non-interference" has fostered experimental approaches to civic energy provision in Bristol (Torrens et al., 2018). More to the point for the purposes of my research, Bell & Sweeting (2013) empirically analysed a specific neighbourhood in Bristol and found significant inequalities around waste collection. Closely resonating with the foundational principles of critical institutionalism (albeit they used environmental justice in their theoretical framework), Bell & Sweeting (2012) argue insufficient attention had been paid to the stark power differentials between the impoverished communities who tend to bear waste-related injustices and those producing waste and profiting from its trade. Waste governance policy in Bristol is a product of a complex history of jurisdictional overlaps between the European Union (EU) and the United Kingdom (UK), which ended when the UK left the EU. But, for the sake of argument, international instruments such as the EU landfill directive historically translated into national legislation (UK Waste Strategy 2000), and this precipitated in a mandate for local authorities like Bristol to reduce waste sent to landfill (Bell & Sweeting, 2013). This was effective: recycling rates have risen from 12.8% in 2004/5 to around 47% in 2012 – but that figure has plateaued and is at the same level today (Bristol Evening Post, 2011; Bristol Waste Company, 2022). Perhaps not as stark as in Cape Town, but there are notable disparities between different social groups in Bristol – which was underscored by their first-hand accounts of the unaffordability of council-led waste services (Bell & Sweeting, 2013). In a study focused on the impact of effectively reducing waste and increasing recycling rates with a FEW nexus and CE in Bristol, Eaton et al. (2022) argue that national policy-making calculations should take into account local variability. Food waste collection for recycling is undertaken by Bristol City Council free of charge (Eaton et al., 2022). Yet, in contrast, Eaton et al. (2022: p. 16) find that a

20% increase in food waste recycling in Bristol has "*no financial benefit to the household*". Eaton et al. (2022) propose food waste reduction and improved equity of access to food supply as solutions to the problem of persistently high levels of waste, with optimisation or environmental accounting potentially serving as means to that end. The point remains, however, that recycling is not necessarily conducive to waste reduction; and any waste reduction strategy or policy must attempt to contribute to the reduction of existing socio-economic inequities (Eaton et al., 2022).

3.2.2.3 Rotterdam

Rotterdam received municipal rights in 1340 some decades after a dam had been constructed in the river Rotte on the site of the present Hoogstraat (High Street). Since then, it has developed from a fishing village into one of the largest port cities in the world and hence an international centre of trade, transport, industry, and distribution (RUAS, 2021). The population is approximately 650 000. At the start of the Second World War, on 14th May 1940, the city was almost completely destroyed by German bombing (and later Allied bombs). Reconstruction took priority after 1945. The city has recently transformed: port facilities moved away from the centre towards the sea, its economy has changed, the population is diversifying, and post-war reconstruction has been completed (Nientied, 2018). Rotterdam is also pursuing urban sustainability and a fresh, "green" identity (Russell et al., 2019). In three Dutch case studies, the perceived and real shortcomings of traditional, hierarchical local government (such as a lack of "entrepreneurial spirit") institutions managing waste have prompted hybridisation to more business-like management styles whereby employees are held more strictly to professional standards and the bottom line (financial efficiency) becomes supreme (Karré, 2020). In combination with this explicit coalescence of business logics and public power, populism has become a distinct characteristic of Rotterdam's political landscape, including anti-immigration politics and a resistance to integration (van Ostaaijen, 2019; DutchNews.nl, 2022). Regarding waste, solutions have remained true to Rotterdam's industrial past – with the local authority playing a coordinating role harnessing individual experts and academic institutions in the design, and businesses in the implementation, of energy and water CEs (Lenhart et al., 2015). It should be noted that Rotterdam, and The Netherlands more generally, is renowned for its water related engineering expertise which has significantly expanded liveable and arable land surfaces. But, as in Cape Town and Bristol, poverty and inequality are persistent challenges in Rotterdam; indeed, Rotterdam has the highest level of poverty in the nation at 10.9% (Geoffrey & Yue, 2020). Literally transposing market semantics to the social sphere, Lenhart et al. (2015) highlighted the relational nature of "urban symbioses" (advancing from the CE precursor, "industrial symbioses") – which aligns closely with contemporary notions of governance (Rhodes, 1997; Kooiman, 1999). Investigating industrial symbiosis as an implementation of the CE concept in Rotterdam and other

European cities, Steenmans (2021) analysed the role of property rights as a legislative cornerstone of capitalism. The development of information and communication technologies has emerged alongside incentivising international CE policies in the EU (Steenmans, 2021). This development has amplified the interactive and interdependent CE networks as a waste governance system in Rotterdam. However, while much was highlighted on these networks, issues of inequality were not addressed in this important study of waste ownership. Steenmans (2021) illustrates the labyrinth of technicality institutionalised agents must navigate to give or take responsibility for ownerless (res nullius) waste in Rotterdam for non-economic ends. "*The current EU context appears more favourable to private property regimes as they are central to the existing capitalist economy*" (Steenmans (2021: p. 9) paraphrasing Screpanti (1999)). Overall, these insights are indicative of a waste governance regime in Rotterdam that is conducive to commodification. This raises questions about what outcomes may emerge in its local socio-economic fabric as a result.

3.3 Social network analysis

In this section, I explain the method and procedures used to identify institutions which align with the CE and FEW nexus concepts in Rotterdam, Cape Town, and Bristol. This first method in the overall mixed method approach is mainly designed to answer my first research question (Section 1.8). However, as I explain later in this chapter (Section 3.6), the mixture or integration of this first method with those that follow ultimately serves to inform answers to the remaining research questions as well (Fetters et al., 2013). In Section 3.3.1, I explain my application of a specific social network analysis tool. In the main, said application is focused on investigating the profile and structure of urban waste governance systems composed of institutions that discursively align themselves with either (or both of) the CE or the FEW nexus concepts – and align with each other. Then, in Section 3.3.2, the data collection process is presented in more detail. And I present key advantages and limitations associated with this method in relation to my research in Section 3.3.3.

Social network analysis (SNA) assumes that social structures and -life are created and manifest themselves primarily through the relationships and the patterns that these structures form (Marin & Wellman, 2011). Social networks are formally defined as sets of nodes (or network entities) connected by one or more types of relations (Wasserman & Faust, 1994). A social network is a set of socially relevant nodes connected by one or more relations. Nodes, or network entities, are the units that are connected by the relations whose patterns are studied in my research. In both the physical and social sciences, there has been an exponential increase of academic interest in, and applications of, network analysis (Borgatti et al., 2009). As Borgatti et al. (2009: p. 892) allude to, social network theory and its universal terminology address a problem that has plagued social studies for millennia: "*how autonomous individuals can combine to create enduring, functioning societies*". Linking this approach to the real-world context of contemporary governance (Rhodes,

1997) and the information age, Wellman et al. (1996) originally studied the co-evolution of social networks and, by now archaic, information and communication technologies. Decades later, Bodin et al. (2019: p. 558) position their contribution to network-centric research as "*a comparative heuristic that facilitates leveraging case-specific findings of social-ecological interdependencies to generalisable, yet context-sensitive, theories based on explicit assumptions of causal relations*", highlighting the relevance of this approach to this thesis. I expand on why this quote from Bodin et al. (2019) is relevant to my application of SNA below.

The units in a social network are generally individuals or groups of individuals, but in principle any units that can be connected to other units can be studied as nodes (Marin & Wellman, 2011). Borgatti et al. (2009) argue that social scientists have tended to focus on individual nodes, at the expense of analyses which help us understand the emergent properties of whole networks. This gap is also evident where SNA has been applied to environmental governance. Koch et al. (2021) use SNA in combination with narrative analysis to better understand social relational structures, and how they constitute capacity in collaborative environmental governance systems. To be sure, Koch et al. (2021) offer important advancements of environmental governance theory, but I differ with their approach in several key respects. Chief among which, with regards to my application of SNA in this research, is my doubt that narrative congruence in social relational structures linking individual environmental governance entities *enhances* the dynamics of overall networks.

What guides my distinct application of SNA is my first research objective (Section 1.3): to identify and critically analyse key attributes of the social structures constituting urban waste governance systems in different cities. I target those social structures comprising entities which embody the institutionalised circular economy or food-energy-water nexus concepts. The distinction I would like to highlight is my focus on the *system*, or the network as a whole. But, also, both Koch et al. (2021) and Bodin et al. (2019) explicitly call for comparative case studies. For this method, I use universal terminology of social network theory (Borgatti et al., 2009). More specifically, my analysis is designed to report these network metrics: **average degree** (a measure of the average number of connections each institution has), **maximum degree** (the number of connections the most connected institution has), **total nodes** (the total number of institutions in the network), and **graph density** (a measure of how many ties between institutions exist compared to how many ties are possible); thus, representing granular discursive consolidation for each city.

3.3.1 Application

The purpose of my SNA in this study is to appraise and visualise (map) networks of institutions or entities partaking in the commodification of waste in each of the three cities. SNA is applied here to identify and map relationships between 1) food, energy, water, recycling, and other- (those

go across categories or fit in none of the main categories), and 2) governmental, academic, NGO, business, and finance institutions which align with either the CE or the FEW nexus concept. This analysis includes those relationships which are explicitly indicated on an institution's online profile (see Section 3.3.2). Thus, the appraisal of institutions and their relationships using SNA is simplified to a binary question: does institution X feature in the network, or not, and does relationship X appear to exist based on its online profile, or not? The appraisal thus takes a closer look at *who* is well positioned in the waste governance network of each city. To be well positioned means either having a high number of relationships or being a "gatekeeper", or broker, effectively serving as the go-between which exclusively links otherwise disparate cliques (Borgatti et al., 2009; Prell, 2012; Koch et al., 2021). This is useful, for example, to understand which institutions are most influential in these networks, and thus allows for some insights on where and by whom institutional change (or the resistance thereof) could be effected. Importantly, it is assumed that each waste governance network consists of discrete nodes, representing institutions in this study, which are unequal in terms of connectivity and capacity. Social network analysis software, like Gephi (Bastian et al., 2009; Harvey et al., 2019), enables statistical analysis of networks to simplify measurement of, for example, its interconnectedness, composition, and overall structure.

I have chosen Gephi for my study because its flexible, multi-task architecture offers new possibilities to work with complex data sets and to produce useful visual results. It provides easy and broad access to network data and allows for spatialising and categorical analysis (Bastian et al., 2009). I coarsely categorise each entity according to its i) "nexus type" and ii) "institution type". *E.g.*, "water" and "government". Thus, each institution included in my analysis has two attributes: i) nexus type, which may be food, energy, water, recycling, or other and, ii) institution type, which could be government, NGO, business, academia, or finance. These categorisations are not meant to be complete lists of possible types. Closer conceptual alignment with the FEW nexus in this SNA application is counterbalanced by the opposite emphasis in the research design and literature review, where the problem of commodification and context of capitalism as the foundational social system underpinning institutional change aligns more closely with the CE. As noted in Section 2.1.3, I analyse the institutionalisation of these concepts taken together; including divergences in whether and how these have been institutionalised respectively, but this is done in the discussion (Chapter 5) of results (Chapter 4) rather than data collection phase (Section 3.3.2).

The institution-type sub-categories are based on two rationales: i) data collection and -analysis, and my literature review, suggest that these typify waste governance systems; and ii) behaviours associated with each of these types are relevant to the interpretation of compositional and structural outcomes of this analysis with reference to my theoretical framework. The "recycling"

and "other" sub-categories were added to (FEW) nexus-type sub-categories because of the role-fluidity observed in waste governance institutions in the relevant cities. The recycling and other sub-categories also serve to accommodate the identification and analysis of institutions which seem to align themselves with the CE idea rather than the FEW nexus. Government and business institutions may have developed more generic waste governance functions to capitalise on waste and to utilise the nexus concept and thereby optimise material flows between different sectors. Over and above the addition of the "recycling" and "other" sub-categories, the manual analysis of discrete websites in combination with more automated web scraping provides an opportunity for the inclusion of data describing institutions which overtly align with the CE but only partly or perhaps not at all overtly align with the FEW nexus. I explain the data collection process below.

Each city's SNA is visualised graphically, and "major" institutions are highlighted (labelled) with attributes depicted by node sizes and colours (see Section 4.1). The reason for using "degree" to denote node sizes in half of the visualisations is that direct connectedness (degree) represents the extent to which CE and FEW nexus concepts have been institutionalised in line with the notion of governance elucidated in Chapter 2. That is, the degree metric denotes how many connections an individual node (representing a waste governance institution, in my case) has. More links are visualised by a larger node size (see, *e.g.*, Figure 8). This resonates with the notion of governance elucidated in Section 2.2.1 since the relational and interdependent nature of urban waste governance systems comprises of patterns formed by connections between distinct institutions. Therefore, the more connections any single institution has, the greater role it plays in constituting the system. "Eigenvector centrality" is used to denote node sizes in the remaining visualisations because it represents the role that indirect relationships play in understandings of governance advancing a dispersed notion of power in urban governance systems. Hence, the rationale for denoting node sizes not only as a function of a node's links with immediate neighbours (this dual notation is carried out for each city-specific presentation of SNA results throughout Section 4.1), but also as a function of how many connections its immediate neighbours have is that it provides a maximally decentralised representation of urban waste governance systems (see, *e.g.*, Figure 7).

The "Yiffan Hu" layout (see, for example, Figure 9) was selected because it visually emphasises the network metrics of average degree (indicating the average number of connections each institution has), maximum degree (indicating the number of connections the most connected institution has), total nodes (size of the network), as well as graph density (a measure of what proportion of connections between institutions exist as a ratio of the maximum number of possible connections) (Hu, 2005). Other layouts, such as "Fruchterman Reingold" – which visually emphasises network metrics such as large-scale network structure and the dynamics of large social

networks – are not relevant for this study and were therefore deemed suboptimal (Fruchterman & Reingold, 1991). Importantly, for the distinct combination of SNA and agent based modelling attempted in this study, it is assumed that network metrics such as average degree and maximum degree can be used to indicate relative magnitudes of equitability in the respective governance networks. This is because the combined observation of average degree and maximum degree juxtaposes 1) how well connected the average institution is, and 2) the difference in connectedness between the most and least connected institutions. Note that, in contrast with Duygan et al. (2021), I concur with Koch et al. (2021) insofar as semantic and relational dimensions are of primary importance with regards to aggregate *and* individual waste governance capacity. The importance of this point will become clearer as I elucidate the triangulation of various data streams below, but it should be noted that here I focus on the role of relational and semantic dimensions vis-à-vis "resources" (Duygan et al. (2021). Resources matter, but I do not focus on them at this stage.

Instead, I consider resources in the following section (Section 3.4). Therein, I explain qualitative analysis procedures used to interview some institutional representatives and analyse institutional discourses and financial statements to obtain another layer of data illuminating who benefits from Rotterdam, Bristol, and Cape Town's waste and why. In different ways, both CE and FEW nexus concepts promote the integration and harmonisation of disparate institutions in urban supply chains and public service sectors like water, energy, and agriculture. By extension, this implies new or altered commercial-political relationships between diverse institutions and diverse people that represent them. Nuances of change in institutional relationships cannot be fully understood using SNA, however, SNA tools can inform targeted qualitative analysis. While simple artificial categorisation can be rendered visually in Gephi using colours, labels, layouts, and legends, more nuanced network analysis functions are also built into Gephi software. For example, system-wide statistics such as average degree and graph density, as well as institution-specific attributes such as eigenvector centrality (a measurement of each institution's connections, taking into account the relative connectedness of its "neighbours") can also be calculated and visually represented using nodal size partitioning as a function of whatever attribute is selected and thus highlighted.

The output of categorising the appraised institutions according to conventional clustering is a snapshot of the composition and structure of each waste governance network. First, the relevance of this output is based on the assumption that ideational power is consolidated by social relations through which resources and discourses flow. Thus, the institutional composition of a network offers a glimpse of the power relations that characterise it. Second, partitioning the same network of institutions according to where each would be situated in traditional food, energy, water, "other" and recycling silos serves the purpose of measuring the relative integration and

connectivity between these. Hence, this opens up an opportunity to test FEW nexus ideas against the network composition and structure of each city under study (recycling and "other" categories align with the CE). Given the simplicity and limited representativeness of sampling as well as the constant flux of involved institutions, the results/outputs are temporary in nature and prototypical.

3.3.2 Data collection

Basic primary data was collected by web scraping information from individual institutional websites. Web scraping is a relatively new form of data collection that capitalises on the vast array of behaviours and interactions that occur and are stored online by agents around the world (Bradley & James, 2019). The purpose of web scraping in my research is to capture a snapshot of the waste governance profile of each city. More specifically, the attribute of interest in each web scraping cycle was partnerships or associations between identified institutions in a city's network. The sample of institutions was generated with the Google search engine using keyword phrases "circular economy X", "food, energy, water waste recycling X", and "food-energy-water nexus X" with X = each respective city. Each city's web scraping cycle generated a unique sample of relevant institutions ranging from local governments, businesses, academia, NGOs, and finance.

The main selection criterion used to "filter" outputs was that a qualifying datum had to be a self-contained web domain in the "www.abc.something" format. This is because subsequent analysis demanded that each datum be a unique, machine-readable signifier. Each eligible datum had to contain the precise phrase used in the search, either in its title or textual content. If not, an eligible datum would need to contain explicit reference to another datum in the same city that did contain said phrase. Hence, each identified institutional website was manually appraised for indicators of "connections" or relationships with other institutions in, or discursively related to, the city in question. In the main, well-connected institutions provide a dedicated web page describing or listing current partnerships or past collaborations with other institutions. However, it was difficult to categorise some of these institutions based on their online footprints. This could be because their digital profiles are purposefully curated and leveraged as marketing tools. In such cases, it was necessary to make an informed decision about which category an ambiguous or versatile institution would fit in. Decisions became increasingly well-informed as data collection progressed as the process of cumulative network construction was conducive to data saturation.

The data output was subsequently "wrangled" or processed into machine readable format, which was done in this case by rendering datasets as .csv files using Microsoft Excel. A single web scraping output was then exported as a .csv file, and could, for example, comprise a list of institutional partners available on a particular institution's website which was scraped using the Google Chrome Web Scraper extension (see "Developer Tools" in Google Chrome's options).

These .csv files were subsequently tailored to fit the selected social network analysis software chosen for this study – namely, Gephi. The data format required by Gephi is such that it describes two core phenomena: entities and their connections to each other. For my purposes here, a simplification of either the links (connections) or entities (waste governance institutions) was necessary. The trade-off was made by simplifying the analysis of connections or links to a binary analysis of whether one exists. Thus, the directionality or reciprocity of relationships between institutions was beyond the scope of this SNA, but the nature of individual institutions that benefit from urban waste was not (see also Section 3.4). Hence, a simple qualitative analysis of all individual institutions that were identified using the above outlined systematic search and web scrape process was conducted, categorising each according to its broad institution type (government, business, NGO, finance, or academic) and its nexus-waste type (food, water, energy, recycling, or other). In both artificial categorisations, several institutions did not fit unequivocally and could rather be described as existing between or across sectoral boundaries – embodying the FEW nexus principle. Likewise, some institutions are not explicitly located or associated with any of the three specific sectors and can be described as a generic or "other" waste governance institution. Many "other" and "recycling" institutions may be discursively anchored in the CE rather than the FEW nexus concept (see Section 4.1), but this is complex and nuanced. In light of this, I discuss the composition of appraised waste governance networks in Chapter 5.

3.3.3 Advantages & limitations

Some argue that "*the extent to which a given critical mass of interests within a multi-level governance framework produces effective resolution of critical trade-offs can be systematically measured*", and that SNA is a useful tool which can help us to understand why certain policies, interactions, or relationships are effective in some situations and not in others (Kurian et al., 2018, p. 138). This suggests that SNA is appropriate for my research, given the diversity, dynamicity, and complexity of urban waste governance systems. This is relevant because these characteristics pose the challenge of heterogeneity, stochasticity, and a multiplicity of causal pathways, thus complicating the discursive adaptation and implementation of global sustainability goals in distinct urban contexts (Valencia et al., 2019). However, whilst basic indicators of interactions and relationships can be measured and mapped using SNA, more complex, nuanced implications and dynamics must be interpreted by the analyst. There are thus elements of bias and human error.

Hence, this method is limited in its ability to help us imagine alternative outcomes of complex interactions based on novel institutional rules, incentive schemes, or other systemic interventions – for which agent based modelling (ABM) is perhaps more appropriate (Raimbault et al., 2020). The qualitative analysis method I explain in Section 3.4 serves as another stream of data which can illuminate current interpretations of past, present, and future waste governance arrangements

(individually or co-constructed visions of the future). But nor does my qualitative analysis enable us to understand the possible future outcomes of differently imagined and actioned interventions. Again, ABM offers a safe approach to simulate possible chains of cause and effect (Section 3.5).

Similar to Koch et al. (2021), implying another limitation of SNA (its inability to fully account for processes and outcomes of institutional change), Duygan et al. (2021) use SNA in combination with qualitative analysis to better understand the inequality of agents in their ability to influence socio-technical waste management institutions. This combination enabled Duygan et al. (2021) to locate the main concentrations of institutional power, and thereby orientate their analysis of salient determinants of alternative or disruptive institutions. Akin to Lawrence et al.'s (2009) concept of institutional work, Duygan et al. (2021) set out to identify agents who have influence – with "influence" defined as the ability to effect formal institutional change, as in policymaking, or to resist it – in a case-specific waste management regime. This is an approach I also apply for my SNA, but it is Beunen & Patterson (2019) whose advancement of institutional work matches my theoretical framework more closely (for more, see *e.g.*, 3.3.1). Still, Duygan et al. (2021) effectively analyse who is (and who is not) able to affect institutional change *and* what constitutes the agency of such agents to wield their distinct ability. Duygan et al. (2021) are able to do so because they combine SNA with a systematic qualitative analysis. This has been instructive for my methodological design. But before reflecting briefly on the theoretical productivity of Duygan et al.'s (2021) methodological approach, note that my research design differs from theirs in that I do not emphasise what enables relative capacities for institutional work. This is quite similar to my divergence from Koch et al. (2021) (albeit the work of Koch et al. (2021) is closely aligned with my hypotheses and theoretical framework), who set out to analyse the individual-to-collective (narrative) constitution of environmental governance systems. Still, instructively, Duygan et al. (2021) identify resources, discourses, and social networks as the types of "endowments" which constitute the relative capacity of agents to effect institutional change.

In keeping with my analytical framework (systems thinking), I concur with Borgatti et al. (2009) in that there is a need to move away from an analytical focus on individual nodes. And in keeping with my conceptual framework, I concur with Bodin et al. (2019) in that there is a need to more keenly appreciate context and case-specificity in the interaction between research and government policy – especially considering my research problem (inter-related social-environmental crises which share a root cause: capitalism and its neutralisation of critique (Boltanski & Fraser, 2021)). In the latter respect, Duygan et al. (2021: p. 4) do appreciate context in their singular case study. Indeed, their application of Qualitative Comparative Analysis accounts for the complexity which characterises waste management even in a singular empirical contexts' "*multiple conjunctural*

causality". But, in the former sense, Duygan et al. (2021) still conform to the analytical focus on individual nodes by anchoring their investigation into the question that asks, "*what makes some actors more influential than others in the Swiss waste management context?*" Rather than serving to examine the outcome of the relative agency of *individual* organisations, my SNA enables an analysis of the composition and structure of institutional networks of discursive consolidation around CE and FEW nexus concepts, which constitutes urban waste governance *systems*. This directly relates to my theoretical framing, which emphasises the newly diffused composition and structure of contemporary governance systems (Rhodes, 1997), as well as the importance of analysing asymmetries and the ideational nature of power (Vira, 1997). Indeed, unsurprisingly, Duygan et al. (2021: p. 8) found that "*agency is concentrated in the hands of only a small number of actors*", which, in the Swiss context, comprised mainly business and government waste actors. Perhaps much more interesting is Duygan et al.'s (2021) finding that the superiority of social linkages and discourses of an organisation – in combination with superior access to material and incorporeal resources – affords their dominance. Hence, the rationale for my distinct SNA design also directly relates to my conceptual framing, which emphasises the need to *critically* consider global and regional context in the interaction between research and government policy (Boltanski & Fraser, 2021). In light of what I consider to be an unprecedented shift in the manner in which discourse is mobilised – and of the dislocation of decision-making from singular institutions to institutionalised social networks – my application of SNA therefore applies a broader notion of what an instantiation of discourse could be. In the next section, I explain how I analyse two particular instantiations of discourse as powerful ideas (specifically, the CE and FEW nexus ideas), which are imbued with (formal) scientific and pragmatic authority and are mobilised in the (informal) emergent social realm of information technology.

3.4 Qualitative analysis

The primary purpose of the qualitative analysis component of this research is to investigate and critically analyse the role of ideational power (in the CE and FEW nexus concepts) in processes of institutional change in three urban waste governance systems. Its secondary purpose is to reflect on the composition and structure of these three urban waste governance systems analysed using SNA (Section 3.3). This involves an appraisal of the notional influence of ideational power mobilised through the waste governance network within which emancipatory institutional change can be pursued, and through which institutional inertia can be resisted in each city. The design of this method is purposefully broad, thus accommodating the complexity, diversity, and dynamicity which characterises the empirical context and which is expressly associated with the theoretical framing of my research (Rhodes, 1997; Kooiman, 1999). But, in line with my selection of systems thinking as the analytical framing of this research, it is also designed to grasp the indeterminacy,

temporality, and multiplicity which characterises agency in processes of institutional change in environmental governance (Beunen & Patterson, 2019). Like Duygan et al. (2021), the utilisation of qualitative methods for this research advances from and complements SNA as explained in the previous section, thus highlighting the co-evolution of social networks and discourses (Koch et al., 2021). But as noted before, this research differs from both Duygan et al. (2021) and Koch et al. (2021) in that it adopts an ideational conception of *restrictive* power in ideas (Carstensen & Schmidt, 2016), focusing on the institutionalisation of CE and FEW nexus ideas and its outcomes.

In addition, my understanding of the role of resources as a categorical constitutive factor in the relative capacity of institutions is also informed by critical institutionalism, which gives impetus to my *critical* analytical approach to institutional status quos (Whaley, 2018). I also align myself with a wider critique of capitalism as a social system which causes interrelated social-environmental crises and erodes the potential for institutional change which critical analysis could deliver (Jaeggi & Fraser, 2018; Boltanski & Fraser, 2021). However, my conceptual framework for this research also demands sensitivity to context in the interaction between research and government policy. This is important because I expect that my hypothetical assumptions of causality (informed both by theoretical insights elucidated in Chapter 2 as well as results obtained from my SNA (Section 4.1) and my qualitative analysis (Section 4.2)) which are incorporated in my agent based modelling design (Section 3.5) can all manifest differently in the respective contexts of the three cities in question. And of course, as I reflect in Chapter 5, my above outlined hypotheses may be refuted by the combined results of all three methods (see Sections 4.1 to 4.3).

3.4.1 Application

As part of my mixed methods approach, and to, for example, augment results obtained from the social network analysis (Section 3.3), I attended eight workshops and conducted ten in-depth interviews with representatives of some well positioned institutions to inform my analysis of the composition and structure of waste governance institutions and their apparent networks in each respective city. Specifically, these interviewees were selected based on my SNA results within the scheme of my mixed methods approach (Section 4.1, see also Figure 6 for details). All interviewees were representatives of institutions identified in my SNA. Whilst few in number, interviews conducted on the basis of the method set out in this section represent voices in each locality across the sector and provide insights from well-positioned key informants that can speak on topics beyond their own immediate experience of their specific professional roles. As I alluded to in Section 3.2.2, there are important contextual differences between the cities under study. And, as I elucidate in Section 4.1, the relative degree of institutionalisation of the CE and FEW nexus concepts are different in each city. I explain the questions and analysis used to collect and process data for this qualitative analysis below (Section 3.4.3), but it should be noted that I took an

iterative or cyclical approach to allow the data to progressively shape the lines of inquiry I used to elicit data from participants (Williams & Moser, 2019). Hence, my semi-structured interview guide (see Section 3.4.2) evolved over time as they were partly informed by my theoretical framing (see Chapter 2) and partly informed by the nature of discourse mobilised during subsequent interviews. I spoke English to communicate with interviewees throughout interviews.

When referring to an iterative approach, I mean that I allowed the data to "take on a life of its own". Applying a measure of reflexivity, I attempted to take notice of my own positionality and therefore opened the phrasing of my questions to be influenced by my ongoing learning process. Thus, I applied the typical integration associated with mixed methods in qualitative research (Fetters et al., 2013). My positionality (Section 1.6) changed over the course of this research, and the theoretical framework that informed the (re)formulation of my semi-structured interview guide also changed over time. As I show in Tables 1 and 2 below, my line of inquiry gradually moved away from a deterministic and normative style toward an indeterminate and exploratory style. For example, I originally asked "*where is financial power concentrated in your waste management industry (if anywhere)?*", but ultimately restyled the question to "*where is financial power concentrated (if anywhere)?*". The change is indicative of a more open-ended tone with which I sought to elicit a wider spectrum of responses, and to open the analysis to unexpected associations beyond the formalistic realm of waste management. A less restrictive line of causal inquiry aligns with advances in applied critical realism (see Section 3.4.3) (Price & Martin, 2018), and my review of environmental governance and critical institutionalism literature (Section 2.2).

3.4.2 Data collection

This section is special in that I divulge specific results to explain specific methodological choices.

The abductive-retroductive approach I used for this data collection and processing relates to my reading of critical institutionalism, and its philosophical roots in critical realism in particular (Bhaskar, 1979; Tikly, 2015; Stutchbury, 2022). Whaley (2018: p. 142) usefully encapsulates critical realism as a philosophy holding "*that social structure and human agency are recursively implicated in the ongoing reproduction and transformation of social systems*". Herewith I intend to go further by advancing insights from applied critical realism (Price & Martin, 2018). Specifically, my semi-structured interview guide was originally designed to elicit reflections on waste minimisation as an implicit practical consequence of the institutionalisation of CE and FEW nexus concepts (see Table 1). And, since the institutional representatives invited to participate in the interviews were selected on the basis of my SNA results, which were in turn based on a systematic identification of institutions explicitly aligned with either CE or FEW nexus ideas (Section 3.3.3), I expected that answers to my questions would revolve around these ideas and

their implications. But this did not happen. To my surprise, these ideas were only mentioned in singular instances (see results in Section 4.2). Despite the apparent discursive alignment, serving as a common denominator by virtue of which respective institutions were included in my SNA sample, my analysis of qualitative data motivated me to consider the hermeneutic contestations of meaning I inferred from my exposure to this dynamic and complex web of institutional change.

Using abductive reasoning, which "*involves assessing the explanatory ability of multiple theories, postulating the existence of causal mechanisms, in the process of searching for evidence that may shed light on the contingent conditions under which a particular event will occur*" (Tikly, 2015, p. 247), I inferred that the CE and FEW nexus ideas did not hold much *explanatory* value. This was surprising since each now comprises an array of literature (Parsa et al., 2021). Proceeding from my original critique and problematisation of these ideas in (former) Sections 2.1.1 and 2.1.2 – which attempted to advance academic critiques of their failure to address equity and justice – I sought qualitative data which contradicted such critiques. But such contradicting data were not forthcoming. Instead, I heard empirical accounts of *why* the relative positions of dominant institutions were *not* changing, and of *why* equity and justice were thus perhaps being neglected. Notably, some reasons put forward alluded to a dislocation of decision-making and responsibility, as well as intermingled economic-social-political factors *maintaining* institutional arrangements. And, rather than being indicative of unique types of thinking and acting, rare instances of actual CE and FEW nexus concept implementation (in contrast with their discursive institutionalisation) were interpreted as contingent on conditions of political and economic convenience and relations.

Table 1: *Semi-structured interview guide with questions used during early interviews.*

INTRODUCTION
What is your role in the organisation; how long have you worked on nexus related waste issues?
THEME 1: SOCIAL
(How) have your local water, energy and food industries worked together to minimise waste and create shared value? Think about some short and simple success stories and failures.
What social factors would you attribute to effective waste minimisation solutions in your city?
(How) should the policy environment you operate in change to minimise net waste and maximise social justice?
THEME 2: ECONOMIC
Where is financial power concentrated in your waste management industry (if anywhere)?
What role does 1) money and 2) technological lock-ins (such as sunk costs in publicly or privately controlled recycling infrastructure) play in innovative urban waste minimisation?
What funding, taxation (e.g. incentives, polluter-pays principle) can help with equitable improvement of waste minimisation in your city-region?
THEME 3: POLITICAL

What kinds of political factors has your institution encountered in helping to minimise waste?
Please tell me about where and how final decisions are made; are they really democratic?
Are there any other issues to discuss or questions not asked which you think are relevant?

These accounts motivated me to understand the *why* and *how* – by applying retroductive inference, or by "*seeking to establish through forms of argumentation what is basically characteristic and constitutive of the structures and mechanisms*" (Tikly, 2015, p. 247) – of waste *governance* networks that I found by systematically identifying diverse institutions tied together by explicit alignment with CE and FEW nexus ideas. Thus, my comparative case study design was reinforced *ex post facto* since establishing what characterises and constitutes structures and mechanisms is arguably contextual. My choice of environmental governance theory and critical institutionalism theory was thus also reinforced *ex post facto*. The basic definition of contemporary governance I provided in Chapter 1 resonates with interviewee accounts of urban waste governance system characteristics, and apparent contestations of meaning echoed critical institutionalism. Further, selecting "context in the interaction of research and government policy" as conceptual frame was likewise reinforced by direct accounts of how policymaking had not effectively responded to the critiques of CE and FEW nexus in the literature, which I had originally intended to advance. Indeed, some representatives of what appeared to be dominant institutions I was interviewing often held and unwaveringly enunciated critical views, and yet described a lack of institutional transformation. Such responses led me to another stream of literature which contributes to the crux of my theoretical contribution in this thesis: critical sociological perspectives on capitalism.

Table 2: *Semi-structured interview guide with questions used during final interviews.*

INTRODUCTION
What is your role; how long have you worked on CE / FEW nexus waste issues?
THEME 1: SOCIAL
Have water, energy and food sectors collaborated to govern waste?
What social factors promote effective waste governance in your city?
Should the waste governance policy environment change?
THEME 2: ECONOMIC
Where is financial power concentrated (if anywhere)?
What role does 1) money and 2) technology play?
Can financial mechanisms improve waste governance in your city?
THEME 3: POLITICAL
What relevant political factors have you encountered in your city?
By whom are final decisions made; are they democratic?
Are there any other relevant issues to discuss or questions I've not asked?

Before I elaborate on critical sociological perspectives on capitalism which affected (and whose inclusion in my theoretical framing was affected by) the analysis process of this method, I want to draw attention to Table 2 and specifically how it differs from Table 1 above. The transition from Table 1 to Table 2 started emerging at a very early stage during the data collection process. First, I held my ground and indeed persisted in my attempt to elicit explanatory uses of the CE and FEW nexus ideas by adding CE to the introductory question. Second, I removed categorical references to specific institutional forms restricting the potential role which interviewees might play in their own view, as in words like "organisation" or "industry". Third, I replaced leading and normative phrases such as waste "minimisation", "management", "success and failure", and the "creation of shared value" with simple, open-ended references to "waste governance". For example, "*(How) have your local water, energy and food industries worked together to minimise waste and create shared value? Think about some short and simple success stories and failures*" became "*Have water, energy and food sectors collaborated to govern waste?*". But fourth, I reduced the number of such references to waste governance by (mostly) confining it to the first ("social") theme. For example, "*What kinds of political factors has your institution encountered in helping to minimise waste?*" became "*What relevant political factors have you encountered in your city?*". Importantly, I introduced the respective themes explicitly as I was conducting the interviews. The absence of any "material" or "physical" theme in the interview guide reflects a key aspect of my critique of CE and FEW nexus ideas as it is set out in Sections 2.1.1 and 2.1.2. Below, I explain how critical sociological perspectives on capitalism factored into my qualitative data collection and analysis. Qualitative results are partly revealed for methodological reasons here, but these are presented in full in Section 4.2. I integrate it with other results in Chapter 5.

To explain how and why critical sociological perspectives entered the trajectory of my qualitative analysis, I draw from Pilon's (2021) critique of historical institutionalism. In it, he argues against "*codifying common sense*" or "*describing what is going on rather than offering an explanation of what is causing such processes to happen*" (Pilon, 2021, p. 104). Pilon (2021: p. 105) ascribes the "codification of common sense" to a "*hegemonic dominance of positivism in political science as a discipline, particularly the American and American-influenced varieties*". This was particularly instructive in my learning and insights into the subject matter as it developed during the transition from Table 1 to Table 2, and for my related decision to combine environmental governance and critical institutionalism theories. During the very first interviews, I gradually realised that the way my semi-structured interview guide was designed was incongruent with the types of responses interviewees provided. As opposed to managerial or formalistic answers, interviewees primarily used the engagement to reflect critically on plausible explanations for what they generally perceived to be inequitable but still valuable waste governance systems. Not only did I fail to

obtain qualitative data offering much explanatory value imbued in either the CE or FEW nexus concept, as I originally anticipated, but I instead encountered critical perspectives reflecting a complex and dynamic sociological arena of hermeneutic contestation which may easily contradict any deterministic assumptions about how certain institutions of urban waste governance function.

Without originally making any reference to "governance" per se, with its emphasis on relations, interdependence, and dynamic networks of diffused power (Rhodes, 1997; Kooiman, 1999), the data I was obtaining suggested that social relations are fundamental and that some institutions are nothing more than products of learning and adaptation to political context over time (Pilon, 2021). I found no singular, reducible fountainhead of agency in these processes of institutionalisation; I found critical accounts of multi-polar, relational, and unequal processes of institutionalisation. Therefore, I adapted the data collection strategy to sensitise my analysis to such processes and their outcomes – with an emphasis on the structural factors influencing and influenced by them. Without "*overshooting the mark, ending at the equally problematic view that things simply change all of a sudden and for no reason*", like Fraser & Jaeggi (2018: p. 71) argue Foucault did, I reset to begin with "*a theory of society that eschews methodological individualism in favour of one defined by social relations*" (Pilon, 2021, p. 108). The particular theory of society I thus began with is one of capitalism: a social system characterised by an uncritical logic of commodification. But there are diachronic (historical) and synchronic (contemporaneous) varieties of capitalism – again, empirical context patently matters (Fraser & Jaeggi, 2018; Koch, 2021; Pilon, 2021). Thus, over time, my decision to undertake a comparative analysis was influenced by (and in turn reinforced) this qualitative data collection process. Specifically, my decision to standardise and retain some degree of consistency for the questions (Table 1 and Table 2 are not fundamentally different) was influenced by my decision to compare synchronic varieties of capitalism as they manifest in urban waste governance systems (hypothetically) typified by waste commodification.

But going beyond waste governance systems or regimes typified by a logic of commodification as niche examples of capitalism's incorporation of urban environmental governance, some critical analysis of wider sociological context was also necessary to understand *why* this was going on (Pilon, 2021). Moving forward from the brief historical picture of each city I provided in Section 3.2.2, I contextualised interview data with a critical analysis of the online profile of influential institutions identified using my SNA – including financial statements vis-à-vis value statements. Whilst I separated "economic" and "political" themes in the questions, interviewees did not seem to delineate these likewise. Indeed, my critique of CE and FEW nexus literature (including my agreement with secondary literature suggesting there is an excessive economic formalism as well as a corresponding lack of explicit political consideration about their societal import at play) was

partly informed by a discursive predominance of political factors inasmuch as the apparent goal of these concepts (minimising waste or maximising material efficiency) was achieved or not. More to the point, "political factors" did not come across as neatly distinct from economic ones. For example, answers to questions such as "*where is financial power concentrated, if anywhere?*" conflated with answers to the question "*by whom are final decisions made; are they democratic?*"

Far from being suggestive of a classic notion of capitalism as an economic form where trade and industry are mainly controlled by private interests or businesses as opposed to government, the answers to these questions were suggestive of a well-established "*institutionalised social order*" manifesting in seemingly new, emergent waste governance systems (Fraser & Jaeggi, 2018, p. 52). Indeed, I inferred this emergent trend whilst interviewing institutional representatives from each of the three respective cities – and this was surprising considering their distinct properties. This echoed compositional and structural similarities factoring into all cities in the SNA results (Section 4.1), but also brought into question the apparent differences between these places. In Section 3.5, I explain how I extrapolated my SNA and qualitative analysis results in order to synthesise and stochastically simulate such factors affecting the outcomes of institutionalisation.

3.4.3 Advantages & limitations

For my qualitative interviews, the SNA outputs (Section 4.1) were used to inform my selection of interviewees with a priority ascribed to interviewees from those institutions which were identified in the SNA as most connected. However, this sampling technique may foreground the perspectives of precisely those institutions that should be analysed more critically with alternative views from less strategically positioned institutions. Learning from the works of critical institutionalist scholars, the crux of the matter is that we need to appreciate who gains and who loses from current (and similarly who stands to gain and to lose as a result of stasis or change in) institutional arrangements (Vira, 1997). I offset this risk by assuring participants that their views would be reflected anonymously in my results, and thus it may diverge from official institutional positions. With that said, as I show in Section 4.2, a gradual tendency to critique emerged during interviews, which iteratively informed the refinement of my theoretical framework and themes of inquiry. The abductive-retroductive approach I took in systematising this qualitative analysis (see Section 3.4.2 above) led to my inference of the economic-political-social factors affecting waste governance wherein politics and sociality intertwine with a tacit logic of waste commodification.

The qualitative data I allude to here are subjective and comprise oral statements, written documents, and presentations by individual representatives of identified institutions. Financial statements and policies governing some identified institutions were also analysed. Hence, extracts of data are presented *ad verbatim* in Chapter 4 to acknowledge and account for inferential bias.

However, the way I analysed this data remained true to my systems thinking framework and post-positivist epistemology. Practical limitations related to the Covid-19 pandemic dictated that some data collection could not be undertaken in the field as initially planned, but rather had to be done online / electronically, *i.e.*, through workshop discussions and interviews with representatives conducted via Skype, Zoom, or Teams applications. Potentially insightful offline stakeholder views may thus have been missed. Interactions with representatives of institutions that featured prominently in the SNA provided in-depth data about their waste governance network's structure and composition, and the nature of its perceived characteristics as a function of these parameters.

To achieve the primary objective of this method, which is to investigate and critically analyse the role of ideational power in processes of institutional change in three urban waste governance systems, I systematically opened my interview questions to alternative views of what is going on which directly contradicted institutionalised "truth" in each city at that moment in time. The institutionalised "truth" which served as the frame of reference against which I was searching for imaginaries of alterity or contradiction was the logic of commodification in waste governance. To remind the reader why I set out to do this, it is the crucial and emancipatory role of critique in processes of institutional change which I am attempting to transpose into the theoretical sphere of environmental governance using a comparative case study of urban waste (Boltanski, 2011). There is thus an advantage in the uniform application of SNA across all three cities under study, since it is the results (Section 4.1) obtained from the SNA method (Section 3.3) which informed the selection of institutions to invite for interviews. But, at the same time, there may be limitations in anchoring the interviews in a semi-structured guide (which I have explained in Section 3.4.2).

3.5 Agent based modelling

Akin to the contemporary notion of governance (Rhodes, 1997, Kooiman, 1999), agent based modelling enables computational analysis of the interactive and non-deterministic processes of institutional change which culminate in social-systemic emergence (Klein et al., 2018). Capable of simulating a wide range of complex social phenomena, agent based modelling is a method that enables such systematic analysis of the systemic patterns comprising granular behaviour that is difficult to predict, explain, or describe (Mitchell, 2009, p. 2011; Klein et al., 2018). I have selected the open source software called NetLogo for my agent based modelling exercise (Tisue & Wilensky, 2004). NetLogo is a "*multi-agent programming language and modelling environment for simulating natural and social phenomena. It is particularly well suited for modelling complex systems that change over time*" (Tisue & Wilensky, 2004, p. 1).

Agent based modelling tools' ability to simulate individual level behaviour as well as systemic interdependencies (as implied in environmental governance theory (Rhodes, 1997; Kooiman,

1999)) is appropriate for my study. Netlogo, as a modelling environment, also offers modularity (system reconfiguration over time) and context scalability (Tisue & Wilensky, 2004). Applications to date all share the core themes of complex systems and emergence (Byrka et al., 2016; Miyasaka et al., 2017; Raimbault et al., 2020; Raya-Díaz et al., 2017; Tong et al., 2018; Waring et al., 2017). ABM does however have epistemological limitations (see an elaboration of such limitations in Section 3.5.2). Hence, again, the triangulation of SNA, qualitative analysis, and ABM is vital (Figure 6). Simulating observed dynamics of the phenomena in question with perfect accuracy is not the goal in this method. Rather, my simulations of the complex waste governance systems were run iteratively to produce representations of *potential* emergent properties and to understand the relative importance of key factors and assumptions. Namely, to activate the hypothesis explained in Section 1.7, factors or parameters of interest include an interactive set of probabilistic functions which interact with the composition and structure of the waste governance systems in question. Following the design of the SNA in Section 3.3, the design of my ABM explained below serves to create a generic model with sufficient configurational variability to, secondly, "grow" the observed waste governance systems or networks comprising institutions (in the "*quasi-reified*" or semi-concretised sense including material, regulatory, and semantic meanings (Boltanksi, 2011)). Thus, my ABM simulates the development of relational networks comprising environmental governance "entities" as it relates to "narrative congruence" (Koch et al., 2021). However, as I explained in Chapter 1, I problematise this process of "discursive consolidation" and its outcome by emphasising the role of relationships as constitutive of institutions' capacity to do "institutional work" (Lawrence & Suddaby, 2006). That is, I critique the relational dynamic and tendency to domination in processes of institutional change (or institutionalisation) which is informed by my reading of environmental governance and critical institutionalism theory in Chapter 2 (Bhaskar, 1979; Rhodes, 1997; Vira, 1997; Kooiman, 1999). My argument is furthered by critical sociology focused on the emancipatory role of critique in an iterative process of institutional change (Boltanski, 2011; Fraser & Boltanski, 2021), and the need to critique an evolving logic of commodification in such processes (Boltanski & Esquerre, 2017). Qualitative analysis results (Section 4.2) and critical sociological theory pointed to a systemic and emergent pattern of hegemonic institutionalisation in waste governance (Fraser & Jaeggi, 2018).

In Sections 2.1.1 and 2.1.2, I critiqued CE and FEW nexus concepts insofar as the literature suggested that these ideas may constitute discursive instruments or instantiations of ideational power imbued with scientific and pragmatic authority. Anchored in environmental governance theory and critical institutionalism theory, which I dealt with in Sections 2.2.1 and 2..2.2 respectively, I then explained how I elucidated the composition and structure of governance systems embodying the institutionalisation of these problematic concepts using SNA in Section

2.3. And, in the previous section (Section 3.4), I explained how I investigated and critically analysed the ideational power in the CE and FEW nexus concepts by grounding my SNA results (Section 4.1) in a comparative empirical qualitative analysis using a small sample of institutional representatives identified with my SNA. Proceeding from the comparative empirical qualitative analysis results thus obtained (Section 4.2), I explain below how I synthesised and stochastically simulated factors influencing this process of institutionalisation and its outcomes by extrapolating the results noted above. The ABM application (including model- and scenario design) is described in Section 3.5.1. Concomitant advantages and limitations are in Section 3.5.2, and its integration with other methods is set out in Section 3.5.3. Separate data collection was not needed for this ABM application as I designed it based on the SNA and qualitative results as I interpreted them.

3.5.1 Application

The purpose of this ABM application is to synthesise and simulate factors affecting the outcomes of processes of institutional change in three urban waste governance systems by extrapolating structural attributes of, and role of ideational power in, observed urban waste governance systems. This section is a careful, detailed description of the ABM from a modelling / technical perspective. I focus on its integration into the context of my full mixed methods methodology in Section 3.6.

3.5.1.1 Model design

My model design is an adaptation of an earlier model design called "Preferential Attachment" (Wilensky, 2005). I selected this baseline model because it was designed to simulate the development of networks where agents (or institutions, in my design) gain an attracting force as their connections to others are compounded. This systemic phenomenon aligns with my reading of environmental governance and critical institutionalism literature in Chapter 2, as well as with statements made by interviewees about emergent trends of institutionalisation in urban waste governance systems (Section 4.2). Therefore, my visual analysis of typical network structures resulting from the "Preferential Attachment" algorithm resonated with the structural results of my SNA (which I visually present in Section 4.1). I extended or adapted and modified this baseline model significantly by manipulating and building on the existing model code, *inter alia*, by augmenting it with a compositional dimension. My final model code is in Appendix A.

In sum, I introduced four waste types ("food", "energy", "water" and a generic "other") corresponding roughly with FEW nexus categories – with which heterogeneous nodes (waste governance institutions) interact as a function of their identity and relationship with others (which constitutes their waste handling capacity). As in the double layer of institutional identity in my SNA (Section 3.3), each node is assigned "nexus-type" and "institution-type" attributes upon entering the system as a function of the Scenario Settings and Model Settings (see Table 4). As I

will explain in the following section (Section 3.5.1.2), the Scenario Settings comprise the variables differentiating respective city-scenarios from each other. See Table 4. Before I explain the more advanced explanatory phase of this ABM process, below I explain the exploratory phase of the model design which culminated in a sensitivity analysis demonstrating the operation of my generic model's dynamics (see Section 4.3.1 for the results of this analysis). The generic model design demanded a few basic, simplifying, functional assumptions which I list in Table 3 below.

Table 3: *Assumptions made in the design of my generic agent based model.*

Assumption	Description
links = capacity	Relational notion of waste governance capacity. See "capacity-link-influence".
stop at full capacity	Each simulation stops when full waste handling capacity is reached.
constant scenario	Ratio of waste- & institution types remains constant for each simulation series.
flux	The waste governance systems being modelled are ever-changing.
recycling = other	SNA "recycling" and "other" waste categories are merged in this ABM.

The assumptions described in Table 3 should be read alongside information in Table 4 (below) and do not include the conceptual foundation of my generic model design. I explain said foundation below. I make reference to Table 4 throughout the remainder of the thesis, but I present excerpts from it when specific items are relevant for specific sections of analysis in the thesis. The parameters, or "Model Settings", such as "*attachment-stability*" are embedded on the model interface (see Figures 3-5). I demonstrate the functioning of "Model Settings" and "Scenario Settings" in a sensitivity analysis (Section 4.3.1). I also elaborate on the assumptions listed in Table 3 above when engaging with the results that stemmed from it in both Chapters 4 and 5.

Table 4: *Brief descriptions of the Model Settings, Scenario Settings, and main agent attributes.*

	Identifier	Description
Model Settings	capacity-link-influence	Exponential function that sets the sensitivity of an institution's waste governance capacity to its connectedness or the number of links it has with other institutions (depending on their respective types *).
	attachment-expansion	Probability of linking or networking activity beyond its original link that occurs upon entering the network.
	attachment-stability	Probability of links breaking or remaining stable over time.
	disruptor-probability	Probability that a new institution comes in despite its corresponding waste type being adequately handled by the network.
	elimination-probability	Probability that some institutions will be eliminated once a specific waste type is adequately handled by the network.
	attachment-affinity	Probability of preferential attachment to institutions of the same nexus type.
	attachment-idolization	Exponential function that determines preferential attachment to the most connected, or incumbent, institutions.
	elimination-exponent	Exponential function that sets incumbent resistance to elimination.
Scenario Settings	waste (food, energy, water, and "other")	Waste is the principal "substance" with which institutions interact, other than with each other. The quantity of each respective waste type can be set manually on the model interface (the duration of each iteration of the simulation is dependent on the time it takes for the institutional network to "handle" all waste of various types. *I.e.*, the simulation stops at full waste handling capacity *).
	institutions (NGO, business, government, finance, academia)	Institutions are the "agents". All institution types form connections and handle waste. The proportion or percentage of respective institution types in the network can be set manually on the model interface. This setting constitutes another layer of heterogeneity or complexity influencing the formation of connections or links.
Main Agent Attributes	affinity	Model-wide property determining how likely institutions are to preferentially connect with others of the same nexus-type.
	idolization	Model-wide property determining how likely institutions are to preferentially connect with others that are already highly connected.
	capacity	Institution-specific property determining how much waste (of its corresponding nexus-type) it can handle. This is a function of connectedness to institutions of the same nexus-type, as well as any links to others of the same institution-type but different nexus-type *.
	nexus-type (correlate of waste-type)	Institution-specific property determining what type of waste it can handle and with which others it is probable to connect. This property is a function of the amount of various waste types in the system, which is manually set on the model interface.
	institution-type	Institution-specific property influencing whether any given connection or relationship adds to the capacity of either of the two connected parties. The proportion of various institution types represented in the model is manually set on the model interface.

*These are extensions of the model that can be manually activated or deactivated by the operator on the model interface.

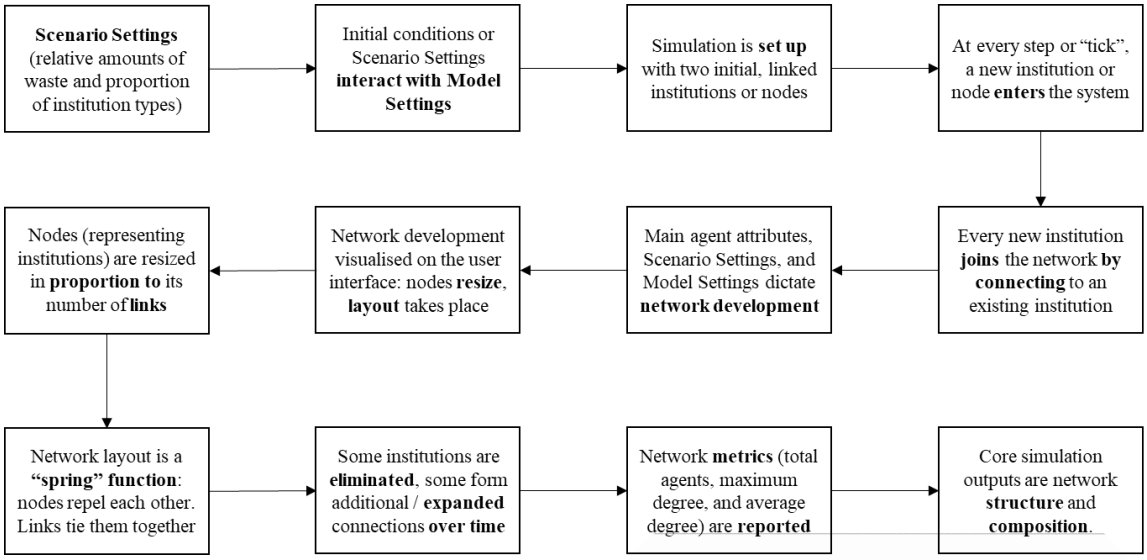
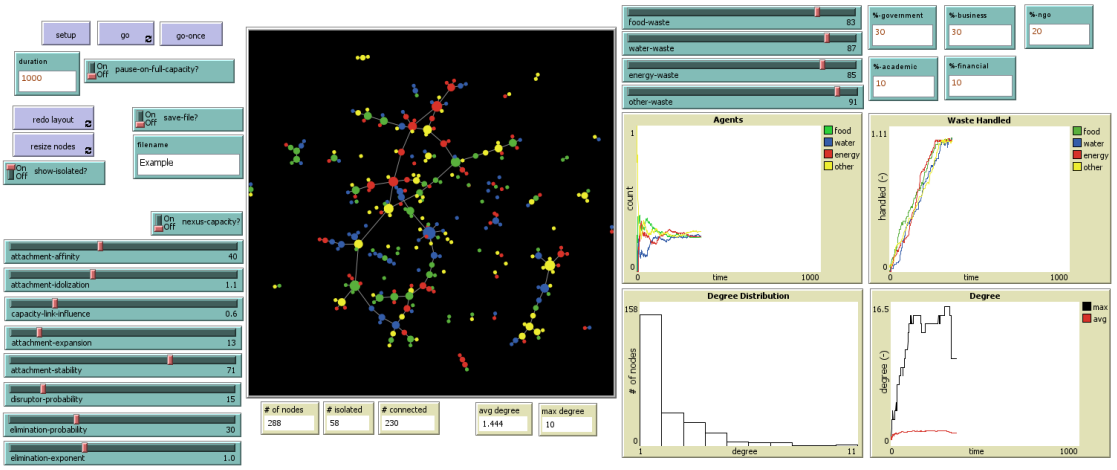


Figure 2: *A process flow diagram illustrating how each phase or step of the simulation sequence is implemented. Final "system equilibrium" is functional rather than theoretically representative.*

In Figure 2, I illustrate the sequence of operations comprising a simulation run. The primary points of departure in the model setup are Model Settings and initial conditions, or Scenario Settings. These two configurations interact, determining the pattern of connections formed between nodes. The network's growth or development starts with two connected nodes – and the identity of those two nodes is a probabilistic function of the Scenario Settings. More specifically, the composition of the ultimate waste governance network or system being simulated mirrors the manually set relative proportion of institution-types and waste-types (a feature designed to mimic the SNA design in Section 3.3). Growth or development of the network happens one step or "tick" at a time – with a single node entering the system at every tick or time step. Each node enters the system by linking with another node that is already in the system. Node sizes change with every tick, as does the overall layout of the simulated network. Node sizes represent their levels of connectivity. A "spring" function pushes all nodes away from the centre, with connectivity to other nodes acting as an opposite force holding well connected nodes nearer to the centre of the modelling interface. Over time, individual nodes or institutions (which is what individual nodes represent) can exit the system due to elimination, or they can cumulatively gain connections and dominate the system. Network metrics of interest are total number of agents, which is institutions represented by nodes; degree distribution, including graphical representations of degree distribution, maximum degree, and average degree; as well as precise numerical reports of the average degree and maximum degree of the network. In addition to graphical tracking, the total number of nodes is also reported as a precise numerical value. Precise numerical reporting of the total number of nodes that are "isolated", or are not connected to the main network, is coupled with precise numerical reports of the number of nodes that is connected to the main network rather than floating in separate clusters.

Figure 3: *Low-range Model Settings (except attachment stability) interacting with high range, balanced Scenario Settings (high amounts of all waste types and some institutional diversity).*



Figures 3, 4, and 5 show my NetLogo model interface. At the top left, main controls such as "*setup*" (which readies the model for a simulation) and "*go*" (which starts a simulation run) are shown. Also, optional settings such as "*pause-on-full-capacity*" (which determines whether each individual simulation stops when full waste handling capacity is reached by the system as a whole), "*redo layout*" (which activates a spring layout function similar to the Yiffan Hu layout used in my SNA), and "*resize nodes*" (which determines the size of a node in direct proportion to its number of links – as is the case in the visualisation of SNA results to be seen in Figures 8, 10, and 12 in Section 4.1 below). Model Setting sliders are bottom left whilst Scenario Setting sliders (setting amounts of each waste type) and numerical boxes (setting proportions of each institution type) are top right (Figures 3-5). Also shown in Figures 3-5, the key network metrics are reported numerically and graphically (total nodes, waste handled, degree distribution, average degree) bottom middle-right.

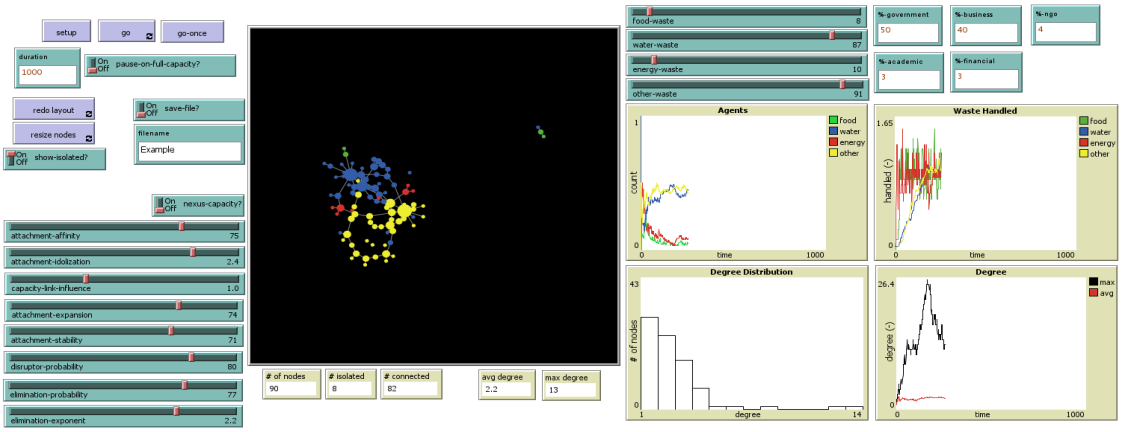


Figure 4: *High-range Model Settings (excepting capacity-link-influence) interacting with imbalanced Scenario Settings (low energy waste, government, and business domination, etc.).*

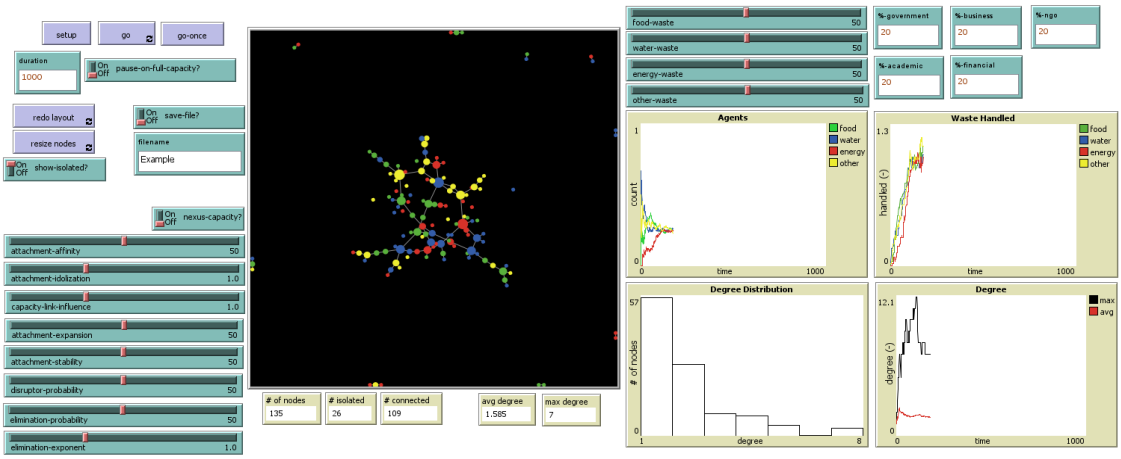


Figure 5: *Model interface with mid-range, balanced Model Settings interacting with mid-range, balanced Scenario Settings (notice equivalent amounts of all waste types and institution types).*

Whilst the quantitative network metrics (average degree, maximum degree, and total agents) were reported in each simulation run, the resultant network's structural profile was visualised in a manner that is comparable to the Yiffan Hu network layout of SNA results (Section 4.1) that was used in Gephi (Section 3.3). Variable "behavioural" parameters (see Table 4) are located on the left-bottom side of the user interface, whilst scenario specifications are located at the top-right (Figures 3-5). Network visualisation can be seen at the centre of the interface, whilst quantitative network metrics are plotted and gauged at the bottom-centre and bottom-right (Figures 3-5). Notice the stochastic interdependence and interactivity of Model Settings and Scenario Settings.

In order to navigate the stochasticity, a sensitivity analysis was done to demonstrate the influence of each Model Setting in terms of three reported metrics: total agents (with the same meaning as "total nodes" in the SNA), average degree, and maximum degree (Section 4.3.1). This was done using a tool within NetLogo called BehaviorSpace. BehaviorSpace enables the NetLogo user to run numerous simulations with a predefined schedule of parametric variance. In the sensitivity analysis I applied to understand the dynamics of my model design, the weight of each Model Setting was demonstrated by using BehaviorSpace to run a fixed number of simulations with each Model Setting or parameter set to its minimum (0) and maximum (3 or 100, depending on whether it is an exponential or probabilistic function), as well as 9 increments. BehaviorSpace thus allows for a very large number of simulations to be run and reported without manual human operation.

3.5.1.2 Scenario design

To operationalise scenarios, as outlined above, I designed my general model to accommodate sufficient variability and so to adequately reflect contextual differences between cities. A key feature of my generic model design, as described in Table 4, is heterogeneity. Agents, construed as waste governance institutions, are diverse (both nexus- and institution-type attributes) and

interact with each other as well as a variety of corresponding waste types. My generic model is thus exploratory: the point is to analyse outputs collectively in search of overarching properties that might emerge given initial conditions and suspected dynamics. These initial conditions and suspected dynamics are built in as an extensive choice of Model Setting configurations for each simulation series. Although the dynamics built into city-scenarios were informed by SNA datasets based on real waste governance systems (understood as networks of institutions tied together in their alignment with the CE and FEW nexus concepts; see further detail Chapter 2), the purpose of exploratory modelling is not necessarily to calibrate simulation outputs with measured states in the target system(s) (Desjardins et al., 2020). Only in the final modelling phase, my generic model was "fitted" to each observed or appraised city-scenario by, firstly, using the results of my simple analysis of the significance of parameters, *i.e.*, "Model Settings" in Table 4 (Section 4.3.1), and, secondly, adjusting these parameters in descending order of priority (starting with Model Settings that proved to be most influential in affecting reported structural and compositional outcomes of average degree, maximum degree, and total agents) to reproduce observed network structure as a function of manually configured Model Settings in constant, city-specific compositional scenarios (Sections 4.3.2-4.3.4). This final modelling phase was, for each city, related to SNA results. I elaborate on the triangulation of the results across my overarching mixed method approach in Section 3.6 below. In sum, the composition of each city's waste governance system informed manual configuration of waste- and institution-type ratios on the ABM interface – relative to which parameters were then manually configured in order to reproduce a system or network with consistently similar network metrics. The first phase (design and sensitivity analysis) was exploratory, and the final phase (city-scenario calibration) was explanatory (Desjardins et al., 2020). Whereas the exploratory phase of my model is not purposed to calibrate simulation outputs with measured states in the target system(s), the explanatory phase is. The exploratory modality of my model serves to demonstrate the inherent dynamics of its design and therefore makes its internal workings transparent, whereas the explanatory modality serves to help us understand how or why the target system came to be (as a function of parameters of interest) (Desjardins et al., 2020). Detailed results are presented in Section 4.3 and discussed in Chapter 5.

3.5.2 Advantages & limitations

Whilst establishing my theoretical framework in Chapter 2, I emphasised the mercurial nature, or dynamicity, of both environmental governance and capitalism because, as I noted in Section 2.2.2, it is a key attribute in the context of my research design which partly motivates my comparative empirical study and my overall triangulated methodology – including ABM. Up to this point, I have said much about environmental governance (as well as governance theory more generally, and waste governance as a particular example), but I have not said as much about capitalism and

how my understanding and problematisation of that societal form factors into my methodology. In Section 2.2.2, where I reviewed critical institutionalism literature in the framing of my research, I engaged with the theoretical tension between approaches which emphasise structure on the one hand, and those that emphasise agency on the other hand. The former is often seen as restrictive whilst the latter can be thought of as liberatory; but I reject this dichotomy. Fraser & Jaeggi (2018: p. 71) concisely enunciate a similar rejection of both structural determinacy or teleology as well as radical alternatives like that of Foucault (1972; 1980), arguing that we cannot suppose "*...an entrenched ... power/knowledge regime simply ends, we know not why, and a new one abruptly appears, but in a way that is entirely unmotivated – as if anything might happen at any time!*". My study sits between such theoretical extremes, and ABM is inherently suitable for such a combined approach (Klein et al., 2018). That is, whilst my ABM emphasises the structure of waste governance systems – there is also a compositional dimension at play representing heterogeneity and contestation among institutions which I consider to be reflective of agency.

There is a simple but fundamental point in situating my research design, and therefore my ABM design, somewhere between the extremes of structural restrictions and agentive liberations: the present is a product of the past, just as the future is a product of both past and present. Again, there is dynamicity (a temporal element) in the institutional change of urban waste governance systems – in addition to the complexity and heterogeneity which I have attempted to incorporate through my application of SNA and qualitative analysis (Sections 3.3 and 3.4). This dynamicity of processes is something an ABM is uniquely positioned to explore and investigate which is why, I argue, it is a useful addition to my trinity of utilised methods. I say more about triangulation in Section 3.6 below, but the ABM method's ability to represent what I call the omnipresence of change in environmental governance is an advantage (Allouche et al., 2019; Partelow et al., 2020).

ABM has limitations too. For instance, it historically had little impact on the social sciences (Klein et al., 2018). To overcome that challenge, I reinforce its continuity with my theoretical framework in this section. One of the most obvious limitations of ABM applications which Klein et al. (2018: p. 10) highlight is their high level of abstraction and their tendency to omit "*potentially relevant features of their target systems*". As I reiterate in the next section, this is partly why I have opted not to collect data independently of the other methods I have employed in this study for my ABM. But, also, and in line with my conceptual and analytical frameworks, this is partly why I frame my entire research design, and therefore this ABM design, in a sociological critique of global capitalism. What I mean by this is that waste governance systems do not exist in isolation from the broader societal structures of contemporary life in cities – and therefore they should not be analysed as if that were the case. Whilst the scope for functional inclusion of different institution

types is naturally limited in my ABM design, serving only as a scenario setting which represents institutional heterogeneity, the fact that I include business, government, NGO, academic, and finance institutions is purposeful and meaningful. Whilst I more fully express the purpose and meaning I ascribe to this inclusion in the SNA and qualitative analysis methods and their results (Sections 4.1 and 4.2), the design of my ABM reflects my understanding of contemporary waste governance systems as extensions or outgrowths of established institutionalised social orders in the cities under study. And the institutional inertia I imply in the synthesis of parameters, or "Model Settings" (see Section 3.5.1.1), reflects my alignment with critical sociological perspectives on how capitalism develops and persists despite its pitfalls (Boltanski & Esquerre, 2017; Boltanksi & Fraser, 2021; Fraser & Jaeggi, 2018). My hypothesis is embodied within my ABM: in each simulation, relational urban waste governance systems develop through a process of institutionalisation. In order to reproduce a statistically consistent mirror-image of the observed waste governance systems in terms of proportional institution- and waste-types (constant Scenario Settings reflecting the compositional initial conditions of a simulation series) and network metrics (reflecting the structural outcome of a simulation series), a range of Model Settings are configured manually. In this way, I identify a configuration of Model Settings unique to each city-scenario. However, it is worth pointing out, an element of equifinality could also be at play here since the reproduction of a waste governance system with a similar composition and structure as those I observed could, in principle, stem from multiple Model Setting configurations. Therefore, conducting a sensitivity analysis is important. The sensitivity analysis also matters because the assumptions of causality implied in the ultimate Model Setting configurations that reproduce observed governance systems in terms of measurable network metrics can also be manipulated and nullified by the human operator.

At an abstract level, my generic ABM design (and, indeed, the original "Preferential Attachment" model design (Wilensky, 2005) which I adapted for the purposes of my research) represents a dynamic and interactive system wherein institutions connect with each other and thus gain and confer relational power – a process which I construe as ideational. Using abductive-retroductive reasoning in my interpretation of both SNA and qualitative analysis results, I infer waste handling capacity as a function of connectedness (where the weight of this connectedness function is in turn an exponential function of the adjustable "*capacity-link-influence*" Model Setting (see Table 4)). Serving as conceptual foundation of Wilensky's (2005) "Preferential Attachment" ABM design, around the same time as Rhodes (1997) and Kooiman (1999) were advancing governance theory, Barabasi & Albert (1999) found that growth and preferential attachment are two core features of real networks which models up to that point had failed to incorporate. And, reinforcing

my interdisciplinary theoretical framing, Barabasi & Albert (1999: p. 8) posited that factors which influence generic network development over time (growth and preferential attachment)

> *could explain the origin of the social and economic disparities governing competitive systems, since the scale-free inhomogeneities are the inevitable consequence of self-organisation due to the local decisions made by the individual* [nodes]*, based on information that is biased towards the more visible (richer)* [nodes]*, irrespective of the nature and the origin of this visibility*.

3.6 Integration

It should be clear that the processes and outcomes of institutional change in urban waste governance systems are hypothesised to be both structural-constrained and agentive-liberatory. This is the premise of critical theories of capitalism with which I align myself in this research (Fraser & Jaeggi, 2018). It relates to my reading of environmental governance theory's trajectory and its nascent complementarity with critical institutionalism theory (Beunen & Patterson, 2019; Koch et al., 2021). As I have explicitly noted in Section 3.1 and have also alluded to throughout Sections 3.2 to 3.5, the combination of SNA and qualitative analysis is complementary and thoroughly informed by my critique of literature in Chapter 2 – as is my choice to undertake a comparative empirical study of three cities. My ABM attempts to extrapolate the "snapshots" of waste governance systems in each of the three cities which I obtained using SNA. It should be noted that both SNA results and qualitative results (Sections 4.1 and 4.2, respectively) informed this attempt. It was a challenge to factor in temporal contingency in a process of institutional *change* with compositional and structural determinants and outcomes which – at the same time – vary in their weighting and configuration depending on the local context. Importantly, in trying to do this, I had to maintain some degree of analytical consistency across contexts for comparative and theoretical purposes that would enable the development of more generic conclusions.

This chapter detailed how my methods (and their combination culminating in the ABM design explained above) were developed alongside my research rationale (Section 1.4). Figure 6 (below) summarises the triangulation undertaken to integrate the various results emanating from the mixed methods. My SNA results shaped my qualitative analysis design in three important respects. First, apparently dominant institutions or nodes determined the sample for my qualitative analysis in that I prioritised sending invitations for participation to those institutions with the highest number of links. Second, the design of my SNA meant that the networks it resulted in comprised institutions aligned (explicitly) with CE and/or FEW nexus ideas – and thus served as a starting point for the formulation of questions to ask interviewees. Third, the structure and composition of the networks informed the content of overall themes and questions asked during interviews. Next, Barabasi & Albert (1999) informed Wilensky's (2005) preferential attachment model – and

the structure of said model was consistent with my SNA results. This parallel, in addition to my reading of environmental governance and critical institutionalism theory, informed my first sub-hypothesis; that is, highly interconnected social structures constituting urban waste governance systems foster conformity to the ideational power in circular economy and food-energy-water nexus ideas. In turn, my reading of critical institutionalism theory (and certain critical sociological theories) informed my second sub-hypothesis: that is, that the mobility of, and power in, capitalist ideas imbued with scientific and pragmatic authority restricts conceivable solutions for the problem of waste in cities to adaptive commodification. But this second sub-hypothesis was also informed by my qualitative analysis results (Section 4.2), as was my decision to select environmental governance theory in my theoretical framework. This relates to the approach I used to analyse qualitative data systematically as described in Section 3.4. As noted above, the purpose of and approach to integrating these methods and their results is summarised in Figure 6 below.

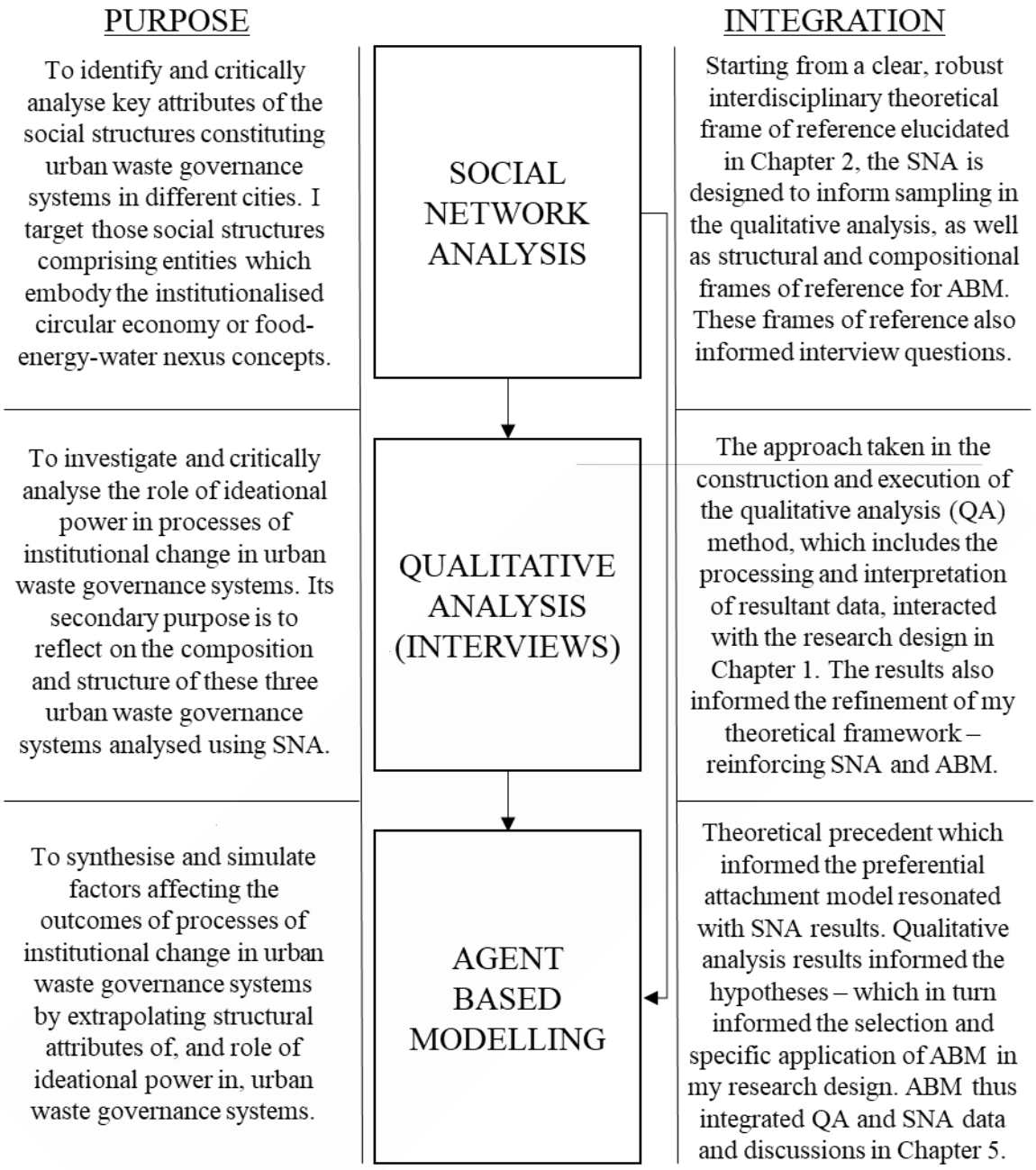


Figure 6: *A schematic visualisation of the three-pronged methodological framework used for the purposes of this research, emphasising the essence of my rationale for mixing these methods.*

In turn, my systematic analysis of interview data relates to my (transdisciplinary) systems thinking analytical framework and conceptual framework which focuses analytical attention onto context in the interaction between research and government policy. Conceptually, abductive reasoning is confluent with systems thinking, as well as with the exploratory nature of my ABM method's first phase (generic model design) (Tikly, 2015). Likewise, retroductive reasoning is conceptually confluent with analytical focus on context in the interaction between research and government

policy as well as the explanatory nature of my ABM method's final phase (configuring parameters with city-specific scenario settings to grow waste governance networks that are compositionally and structurally akin to those observed within the SNA). Beyond the generic features of dynamic real-world networks (growth and preferential attachment, according to Barabasi & Albert (1999)), as I alluded to in Section 3.4, I have inferred that new critical theories of capitalism might explain the qualitative patterns across city-specific contexts which I have identified and analysed through my interviews (Boltanski & Esquerre, 2017; Boltanski & Fraser, 2021; Fraser & Jaeggi, 2018).

In closing, the aforementioned theoretical trajectory (and the methodological design with which my theoretical trajectory interacted in a mutually constructive manner, as I have explained above) brought me to my final sub-hypothesis; that is, that the evolution of institutionalised urban waste governance systems, as diversifying networks of waste commodification, is predominantly influenced by stabilising and expanding factors. There is conceptual confluence between the dynamicity of contemporary environmental governance systems (Allouche et al., 2019; Partelow et al., 2020) and my critical approach to the role of active and passive processes of institutionalisation in such systems (Beunen & Patterson, 2019; Koch et al., 2021). In other words, the third and final sub-hypothesis intertwines crucial but divergent factors of constant change, unintentional structural determinants, as well as intentional agentive determinants. In conclusion, therefore, it is my reading of the theoretical and methodological confluence of governance theory (Rhodes, 1997; Kooiman, 1999), network theory (Barabasi & Albert, 1999; Borgatti et al., 2009), and institutional theory (Bhaskar, 1979; Vira, 1997), and my empirical results, which motivated my research design and its adaptation to emerging results. Hence, I emphasise that it is only by virtue of triangulating results obtained from my SNA, qualitative analysis, as well as ABM that I was able to conceptualise the full rationale and design of my research. Importantly, the empirical results also influenced an adjustment of the overall design (see Section 3.4). In the same vein, I therefore argue that it is only by virtue of such triangulation that my research questions as per Chapter 1, which encapsulates my research rationale and design, can be meaningfully answered.

4 Results

In this chapter, I present my research results for each of my three case study cities. I do so by firstly presenting, in Section 4.1, the social network analysis results stemming from the method described in Section 3.3. Then, in Section 4.2, I provide results from the qualitative analysis method described in Section 3.4 for each of the cities. Lastly, in Section 4.3, I present results from the agent based modelling method described in Section 3.5. This includes results from both a generic sensitivity analysis exploring the model dynamics (Section 4.3.1) and a comparative explanatory application of the model to grow networks with attributes similar to those observed using SNA (Section 4.3.2). In order to draw together and contrast the context-specific findings from the different case studies for the different methodological approaches, each section concludes with comparative summaries of city-specific results (see Sections 4.1.4, 4.2.4, and 4.3.5, respectively). Here, it might also be worth noting in advance that cumulative results across all these sections are brought together, triangulated, and discussed in the subsequent Chapter 5.

4.1 Social network analysis

This section contains city-specific and comparative results obtained from the implementation of procedures detailed in Section 3.3. Through these results, I identify key attributes of the social structures constituting urban waste governance systems in different cities. These attributes are structural and compositional and serve to inform and enrich subsequent methods and their results.

4.1.1 Cape Town

The search for online entities that explicitly mention “circular economy”, “food, energy, water waste recycling”, or “food-energy-water nexus” and “Cape Town”, yielded 142 institutions (search conducted in April 2020). Tracing relationships or connections as set out in Section 3.3, the resulting waste governance network has an average degree of 2.085 and a graph density of 0.015 (Figures 7 and 8). Most institutions identified in the search are generalists (*i.e.*, do not fit any nexus category) or offer the broad category of recycling services as their value proposition. In total, 53 identified institutions (37.0%) best fit in the “Recycling” category under the “Nexus Type” classification process. In contrast, 46 (32.9%) do not fit in any nexus category; these are predominantly government-related institutions with wide mandates that also involve waste.

One of the relatively few businesses that features prominently in this analysis is “Y-waste”, a for-profit company specialising in collecting and revalorising food waste, but which is disconnected from the rest of the network (Figure 7). Outside of Y-waste’s closed network of participating restaurants and retailers, very few institutions that embrace the CE or FEW nexus would fit specifically in any of the food, energy, or water waste niche categories. The available

infrastructure for voluntary consumer waste minimisation or independent recycling is owned and operated by the City of Cape Town. Its Solid Waste Management Department controls formal municipal bins and recycling and regulates waste management or governance in the city. The City of Cape Town is linked to the Western Cape provincial government, to the Solid Waste Network, and to the national energy utility Eskom. As in Figure 7 below, the Yiffan Hu layout used to visualise SNA results is a function that causes unlinked nodes to repel one another. This repelling "force" contrasts with the attracting force of connections. For example, Y-waste is distanced from the main waste governance network because it is only connected to one, rather isolated, cluster of partners. All nodes represent an institution identified using procedures set out in Section 3.3.2.

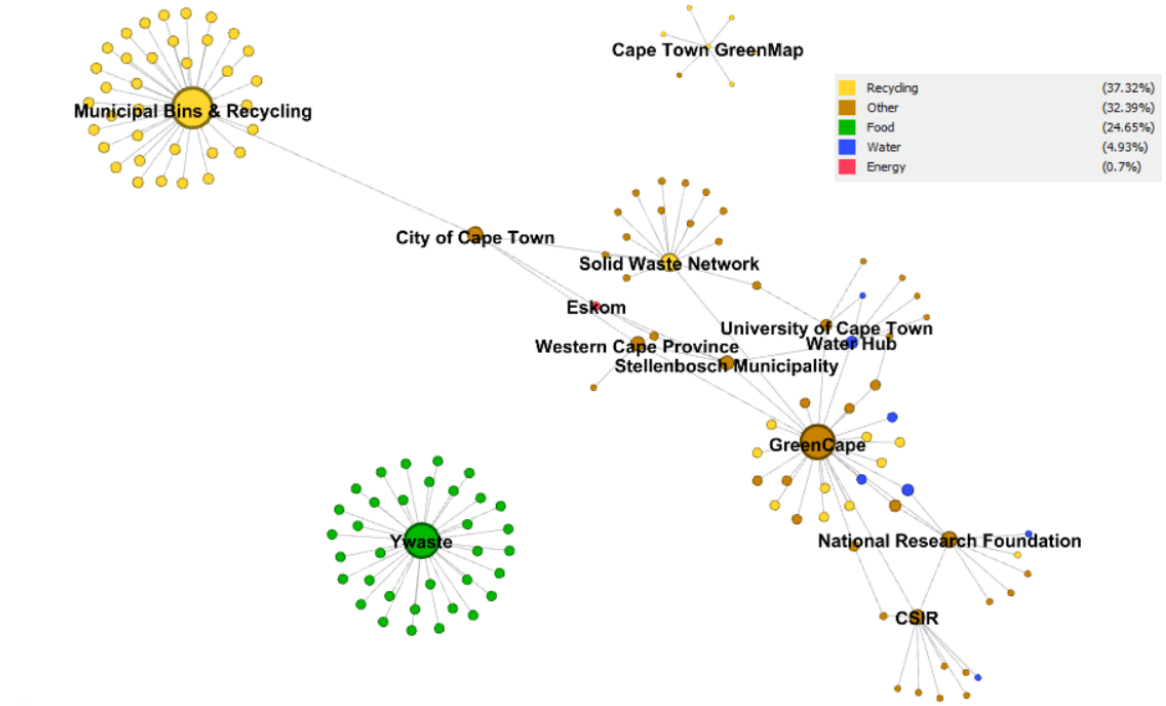


Figure 7: *Waste governance network for the City of Cape Town by sector. Only apparently prominent institutions are labelled. The size of each node represents its eigenvector centrality.*

As shown in Figure 7, there seem to be virtually no institutions that squarely fit in the "energy" category (excluding those occupying multiple waste type categories, rather categorised as "other"). Intending to represent all the nexus sectors, I therefore purposefully added the single exception in the governance network above to illustrate a known structural constraint in the South African energy generation policy environment. At the time of my empirical data collection, it had long been unlawful for households or local governments to purchase electricity directly from Independent Power Producers (IPPs). This means that Eskom, the state-owned utility that rather openly dominates the South African energy sector, enjoys a monopoly under government policy.

Similarly, I also purposefully added Y-waste to this governance network (independent of the data collection procedure elucidated in Section 3.3.2) to illustrate the underdeveloped food waste recycling industry in the City of Cape Town, or at least, its underdeveloped online presence. For example, there is a well-known urban agriculture initiative called the Philippi Horticultural Area (Seeliger, 2020), which forms part of Cape Town's "Cape Flats" region – a fertile flatland where non-Europeans were designated to live at a distance from the city centre and its immediately surrounding white suburbs. The "townships" and informal settlements here are poorly serviced, densely populated, and host a palpable lack of basic infrastructure, which has led to a persistent accumulation of solid and fluvial waste. However, this area is not represented in the governance network diagram (Figure 7), as it has no online presence. The lack of information technology and financial capital in small to medium sized urban agriculture enterprises may explain this. But this may also be indicative of the low uptake of CE and FEW nexus ideas among such institutions. Again, Section 5.3 revisits limitations of the overall research design – including the SNA method.

There is some institutional diversity in Cape Town's "water" category. This may be a result of rapid population growth and the semi-arid status of the natural environment. Policy changes had recently been implemented to control the consumption and waste of water. Specialised institutions have emerged to meet this challenge (see Figure 7). In other words, only "water" institutions (in terms of the FEW nexus) emerge from the data collection procedure described in Section 3.3.2.

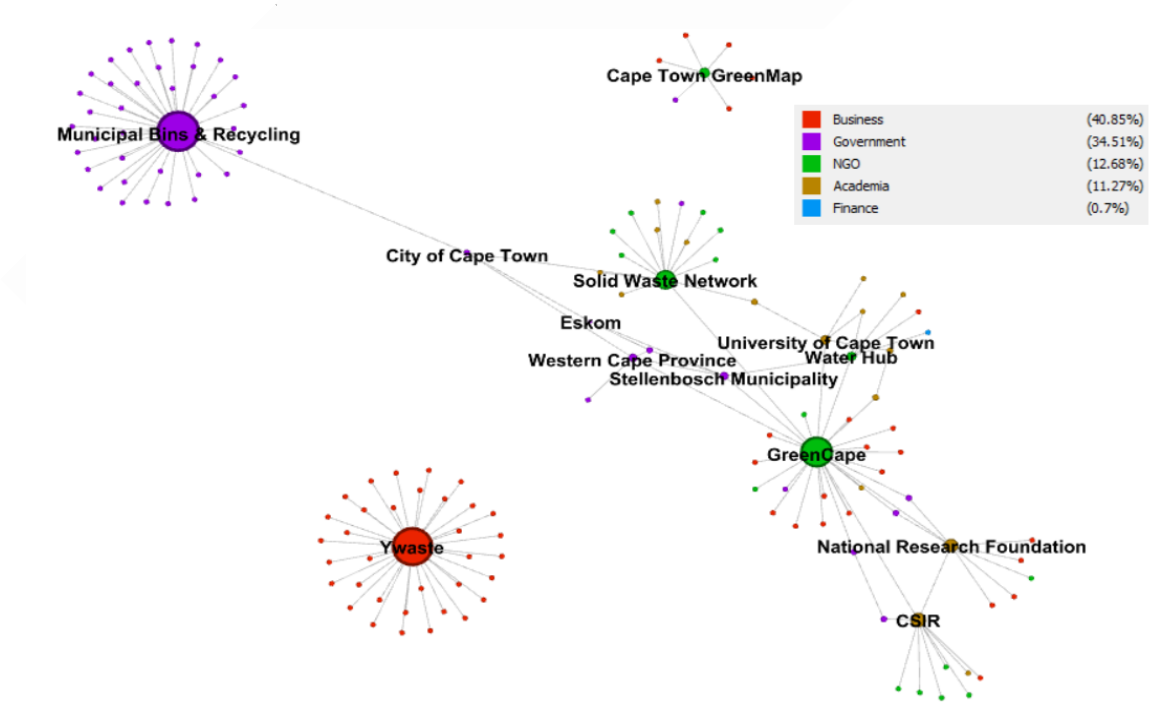


Figure 8: *Waste governance network for the City of Cape Town by institution type. The size of a node reflects its degree (a measure of the connectedness of each institution in the network).*

If those institutions that are not clearly connected to the rest of the appraised waste governance network (Y-waste, in particular) are ignored, Cape Town's network is dominated by government institutions (Figure 8). These include the Western Cape Government, City of Cape Town, Stellenbosch Municipality, Eskom, and Municipal Bins & Recycling (part of city administration). In Figure 8, where node size also represents each node's connectivity inclusive of the connectivity of its "neighbours", these government institutions – apart from Municipal Bins & Recycling – are not particularly pronounced in terms of their connectedness. Instead, their prominence is better reflected by a relatively strategic position (meaning well located as intermediaries between highly connected nodes, thus enabling a "brokering" or "gatekeeping" role to develop) in the network.

Cape Town Green Map is another seemingly disconnected node, which is an independent non-profit organisation which promotes "*green as an informed lifestyle choice*" and seeks to record and promote a "*growing green consciousness"* in the city (CTGM, 2021). It was a temporary project in the Host City Cape Town's Green Goal 2010 Action Plan, which comprised a set of activities to promote Cape Town as a sustainability hub when South Africa hosted the 2010 Soccer World Cup. It is now a fixed local spin-off of a global network headquartered in New York, USA.

Another noteworthy observation in this SNA is the central position of GreenCape, which appears to be the primary connector of various institution types in Cape Town (see Figures 7 and 8). This NGO, or third sector institution (it self-identifies as an operationally independent non-profit organisation), is funded and hosted by the Western Cape Government. GreenCape seems to have an intentional approach to networking and connecting commercial, academic, and governmental stakeholders to facilitate FEW nexus synergies and CE style supply chain innovations in the area.

Informal waste managers or waste pickers, who are institutionally represented in this network by the Solid Waste Network, also feature prominently in Cape Town (Figure 7). Importantly, this is institutionalisation in terms of ideational power; reflected in the discursive, web-based SNA data collection procedure (Section 3.3.2) in line with my reading of critical institutionalism in Section 2.2.2. In practice, unorganised individuals who are impoverished are incentivised to augment poor municipal capacity with the prospect of financial gain from selling recyclable materials to "buy-back centres" or small to medium sized private recycling companies in the city. These companies are relatively invisible in the network presented here, again perhaps due to poor online presence, even though they play an important role in the actual flow of recyclable waste in Cape Town.

The overall network structure is rather sprawled (this is inferred from visual observation as well as network metrics as shown in Table 5), which suggests that some key role players do not relate to each other directly. The linear structure suggests that "gatekeepers" or "brokers" have ample opportunities to ensure that disruptive collaboration between more peripheral institutions cannot

occur to significantly improve aggregate waste governance outcomes without paying a figurative "toll" for access to key institutions with sufficient financial and political capital. However, some institutions, such as Y-waste, are able to create niches without partnering with such "gatekeepers". Similarly, in terms of Beunen & Patterson's (2019) advancement of "institutional work" insofar as it occurs in environmental governance, this structure may also reflect active attempts by local government to protect its institutional dominance and relationships from being rendered obsolete.

4.1.2 Bristol

Bristol yielded only 60 institutions (search conducted in March 2020), including a relatively wide range of niche institutions such as eco-friendly financiers, city council itself, and more focused think tanks and private sector research entities or utilities. Bristol's appraised waste governance network has an average degree of 2.3 and its graph density is 0.039 (see Figures 9 and 10 below).

Energy-oriented institutions feature prominently in this governance system (Figure 9), comprising 14 individual institutions (23.3%). Food waste specialists also stand out in the network, constituting 9 institutions (15.0%). In terms of "Institution Types", businesses appear to be dominant in the network (Figure 10). Several businesses aligned with CE and FEW nexus ideas advertise themselves online as social enterprises that champion environmental and social causes.

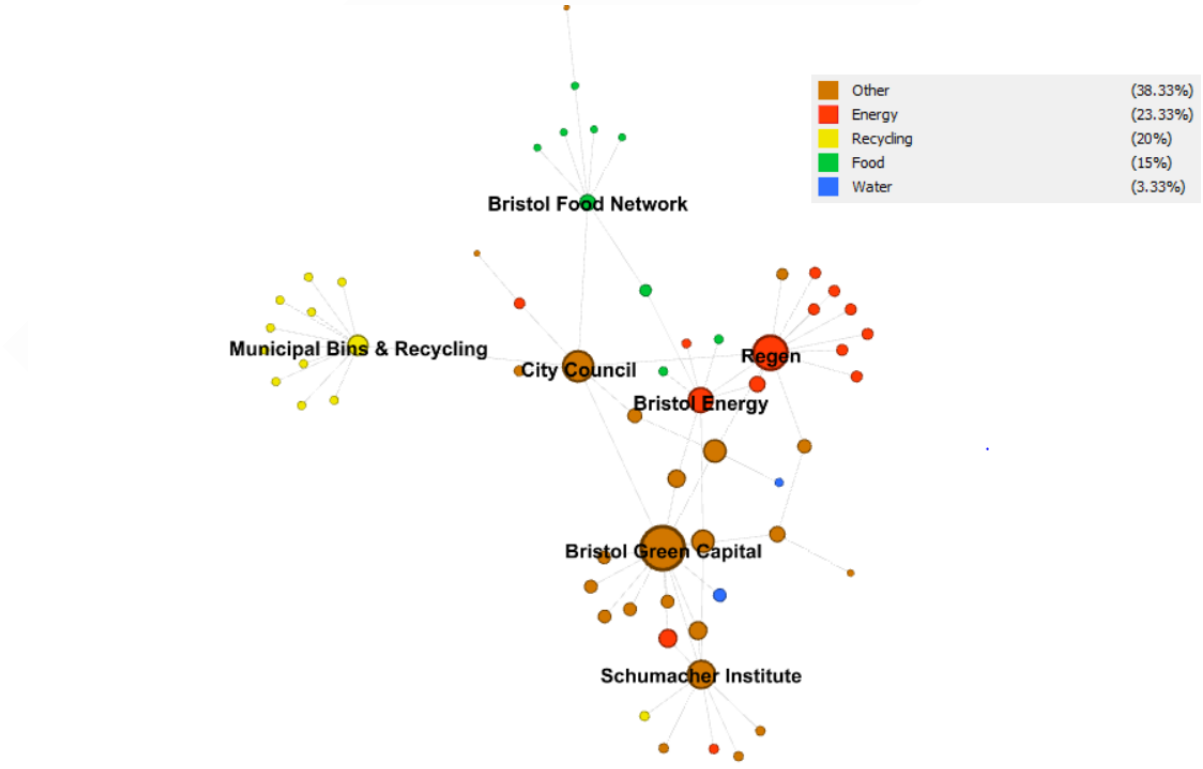


Figure 9: *Waste governance network for Bristol by sector. Node sizes reflect their eigenvector centrality. Specific terms, such as Municipal Bins & Recycling, were standardised across cities.*

In terms of the FEW nexus concept, Bristol's waste governance network appears to include a balanced mixture of institutions focused on energy and food waste commodification. The trend of commodification is inferred from the high degree of entrepreneurship which characterises the online profile of most identified institutions, albeit interspersed with a trend of environmental and social concern. The Bristol waste governance network is relatively interconnected, as evidenced by its high average degree metric (see Section 4.1.4). A wide range of organised civil society (NGO, third sector, social enterprise, etc.), businesses, academia, and local government institutions appear to be indirectly connected in Bristol's waste governance network (Figure 10).

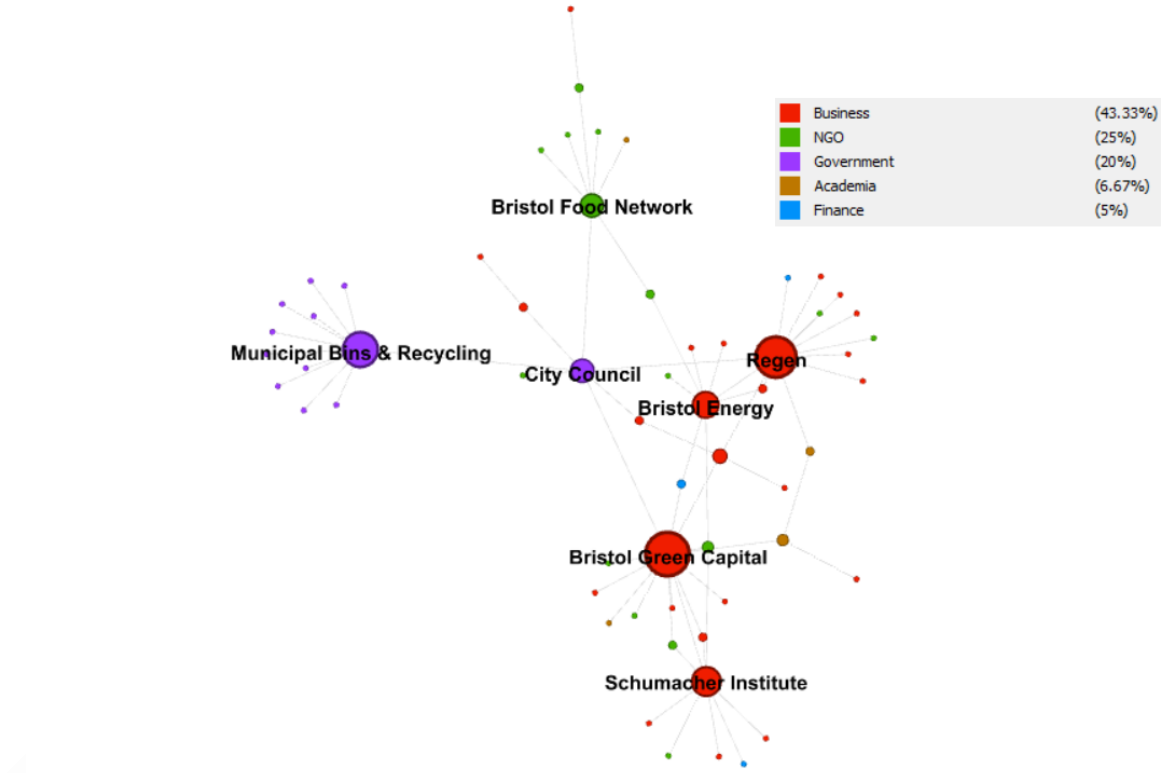


Figure 10: *Waste governance network for Bristol by institution type. Node sizes reflect their degree or connectedness.*

Bristol City Council seems to play a strong coordinating or intermediary role, appearing indirectly involved in the discursive framing of waste governance in the city. To further illustrate the relatively high degree of interconnectedness in this network, consider the Bristol Green Capital collective, a community interest company governed by a Board of Directors who partially represent institutions like City Council, Resource Futures, Sustrans, Triodos Bank, as well as the University of Bristol. Nevertheless, the membership of Bristol Green Capital is highly heterogeneous and expansive. It includes more than 1000 individuals and institutions which go far beyond the scope of my SNA. Notwithstanding, in terms of the specific methodological procedure described in Section 3.3.2, Bristol's institutional network seems more interconnected.

It is visibly compact (Figures 9 and 10). That is, there is a relatively small number of tightly knit institutions that resulted from the online identification of institutions aligning with CE and FEW nexus concepts. The discursive proximity between a diverse range of "alternative" and mainstream institutions related to waste in Bristol is not necessarily indicative of an awareness of the shortcomings of CE and FEW nexus ideas. To the contrary, it could also be indicative of an infiltration of the logic of commodification in the environmental (waste) governance network of Bristol – despite this network's institutional diversity. This ambiguity of some of my SNA results motivates an additional method to obtain some perspectives on the dynamics of, in this case Bristol's, waste governance network(s). Hence, additional streams of data were collected as per Section 3.4. This is necessary to critically review the accuracy of my hypothesis in Section 1.7.

4.1.3 Rotterdam

The online search for Rotterdam identified 181 institutions (search conducted in April 2020). The network's average degree is 2.11 and its graph density is 0.012. It has low levels of "between group connectivity", or links between institution-clusters (see Figure 11). Prominent institutions include Circle Economy, Blue City, and Afval Bedrijven Vereniging (literally translated as Waste Companies Association). However, these clusters seem to be characterised by a high level of networking activity within their immediate sphere of influence. Generalists, recycling specialists, and energy related waste governance institutions are varied and common in Rotterdam. The vast majority of institutions appraised in Rotterdam cannot be neatly categorised as either recycling, water, food, or energy institutions. A combined 25% of institutions fit into the recycling and energy categories (Figure 11), which aligns with the qualitative character of Rotterdam as a highly industrialised, European port city. Networking activities, driven primarily by the largest nodes in Figure 12, are pronounced and easy to trace online. The semi-closed clusters of partners connected to each keystone institution consist of many generalist-affiliate entities in the region. This result suggests that Rotterdam's waste governance network is large, divergent, and relatively developed.

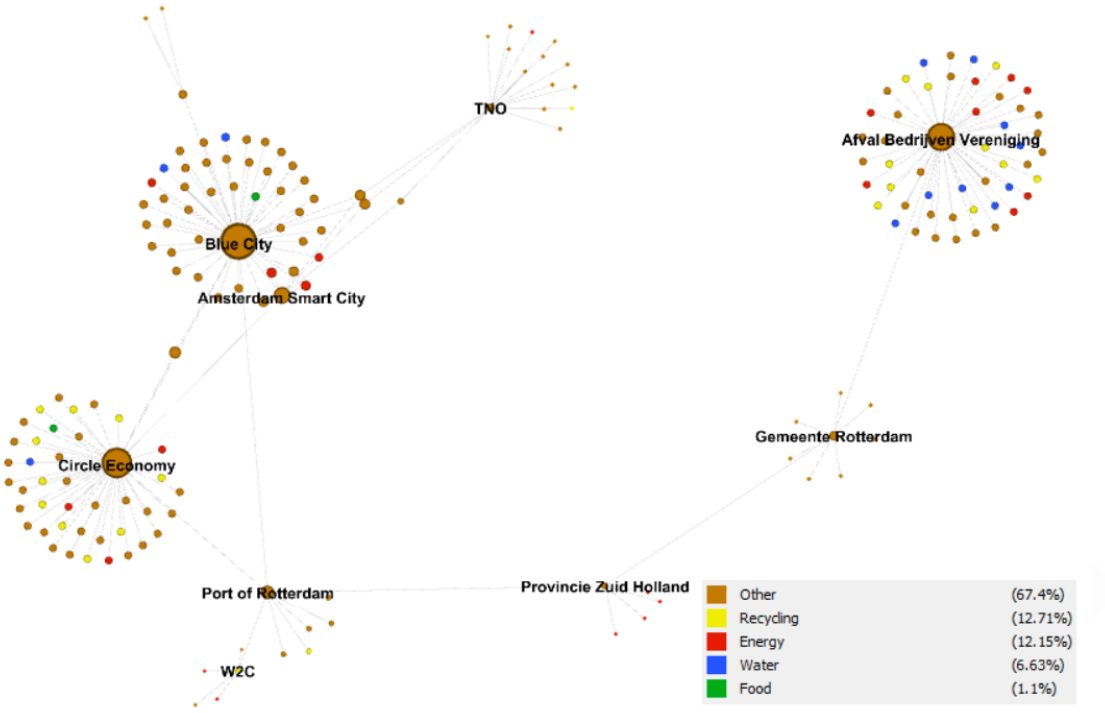


Figure 11: *Rotterdam's waste governance network by sector. Node size indicates eigenvector centrality.*

Perhaps owing to the highly competitive and privatised nature of the waste governance network in Rotterdam, two thirds of all institutions appraised are classified as generalists (Figure 11) – offering a relatively broad range of services to paying customers. Many are large commercial institutions whose target market appears to be big clients, like established industries in the region and local government, rather than single households or neighbourhoods. Household and neighbourhood waste is governed by Gemeente Rotterdam in collaboration with specific companies such as Roteb, which is not labelled in Figures 11 or 12. Rotterdam's waste governance network is dominated by business (n = 136; Figure 12) and only features a small number of NGOs (n = 6). The commercial culture that comes with a network in which businesses comprise more than three quarters of the entire system is likely underpinned by competition and self-interested networking activities. A noteworthy exception with a high level of connectivity in this network is Circle Economy (Figure 12). It is an explicitly not-for-profit organisation that is reliant on philanthropic financial support, and its main targets of engagement are "*businesses, cities, and governments*". However, mainstream, ordinary waste governance institutions and sub-organs of local government may not be as active online as newer, entrepreneurial ventures – and this possibly skews the results here. Still, the small size of clusters surrounding government nodes relative to those surrounding Blue City, the Afval Bedrijven Vereniging, and Circle Economy suggests that government entities are secondary at Rotterdam's vibrant waste commodity frontier.

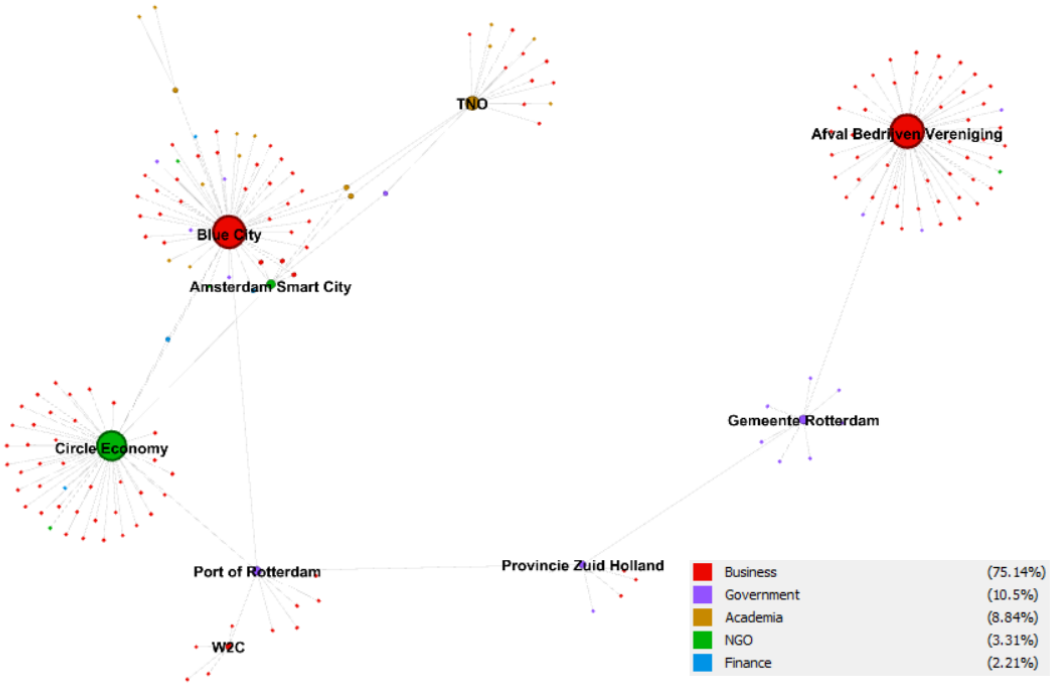


Figure 12: *Rotterdam's waste governance network by institution type. Each node's size is indicative of its degree or connectedness.*

Figures 11 and 12 indicate that there is a high degree of "clustering" (inferred from visual observation) in the Rotterdam waste governance network. Affirmative qualitative associations are made with FEW governance networks wherein "*'high capacity' institutions show high levels of between group connectivity*" (Kurian et al., 2018, p. 134). Conversely, Kurian et al. (2018: p. 133) argue that when institutions "*in a network possess low capacity, they will be part of a governance network that is poorly-connected*". In structural terms, Rotterdam's network is poorly-connected (graph density = 0.012), but certain clusters feature a high degree of nexus-type heterogeneity. For example, as shown in Figure 11, the Afval Bedrijven Vereniging connects a relatively wide variety of waste governance institutions. Whilst the online profile of this institution does not show direct relations with the other keystone or highly connected institutions I identified, high capacity may still be imbued in individual institutions by virtue of their, albeit clustered, links with others.

4.1.4 Comparative overview

In this study, the most important reported metrics in the social network analysis are average degree (a measure of the average number of connections each institution has), maximum degree (the amount of connections the most connected institution has), total agents (the total number of institutions in the network), and graph density (a measure of how many ties between institutions

exist compared to how many ties are possible). These offer comparable quantitative indications of the interconnectivity that characterises each city's waste governance network (see Table 5).

Table 5*: Metrics of appraised waste governance networks in each city.*

	Total Institutions	Average Degree	Maximum Degree	Graph Density
Cape Town	142	2.085	36	0.015
Bristol	60	2.300	14	0.039
Rotterdam	181	2.110	51	0.012

Table 5 should be read alongside Table 7 as the latter table contains information about the context with reference to which these numbers can be compared meaningfully. In terms of conventional FEW nexus categories, energy is the most prominent in both Rotterdam and Bristol (12.2% and 23.3% respectively). Both networks operate in policy environments that promote privatised energy generation where diverse types of institutions try to improve their reputation in accordance with CE and FEW nexus concepts. Heat reticulation from industrial areas in Rotterdam and the production of biofuels from food and water waste in Bristol are both strongly advertised initiatives driven by various institutions. In contrast, Cape Town's energy sector has been constrained by restrictive national policies that do not allow for free competition. Hence, the online footprint of institutions specialising in energy waste recycling or the recycling of liquid and solid waste to produce energy is negligible.

Food waste specialists are prominent in Bristol (15.0%), where an established, well-connected network of institutions and representatives seem to be involved. Food featured strongly in the Cape Town SNA as well, but this was due to an apparently isolated commercial cluster that was not connected to the main network as per my standard data collection procedure. Institutions managing or governing food waste did not feature in Rotterdam's analysis.

Water did not feature strongly in any of the three SNAs. In Rotterdam, singular waste specialists are interspersed in large clusters around powerful generalists such as Circle Economy, the Afval Bedrijven Vereniging, and Blue City. In Bristol, results suggest only two prevalent institutions focused on water: these are linked to Bristol Green Capital (Bristol Water) and GENeco (Wessex Water). GENeco features prominently in Bristol (see also Section 4.2.2), which is partly reflected in its position between Wessex Water, Regen ("*an independent not for profit centre of energy expertise and market insight*" (Regen, 2023)), Bristol Waste, and Bristol Green Capital. However, as with Bristol Waste, GENeco is not labelled in Figures 7 and 8 because of its relatively small number of connections, which is the main metric used in the quantitative analysis of SNA results. This may mean that, as with Y-waste in Cape Town, individual institutional capacity and power do not necessarily correlate with the quantitative magnitude of its relationships with others. In

Cape Town, singular water specialists like the Water Hub are linked to GreenCape, the National Research Foundation, and the University of Cape Town. Institutions in Cape Town align rather loosely with the CE and FEW nexus ideas when compared to those in both Rotterdam and Bristol.

Cape Town's waste governance network comprised the largest proportion of "recycling" specialists (37.3%). The phrase "circular economy" featured most prominently in Rotterdam's sample, whereas the phrase "food-energy-waster nexus" featured most prominently in Bristol's. 75.0% of institutions in Rotterdam's sample were businesses, suggesting a network that is clearly dominated by a logic of commodification. For-profit enterprises (despite constituting 40.9% of the sample) were not closely linked to socially relevant institutions in Cape Town, such as the Solid Waste Network and government institutions like Eskom and the City of Cape Town. Instead, NGOs appear to be trying to interconnect the disparate institutions in Cape Town, but government seems to be at the heart of the network. GreenCape appears to be an influential "gatekeeper" between businesses and other types of institutions, but the full details of its role as a networker cannot be determined through the SNA itself (see also Section 4.2.1). Business is prominent in the Bristol sample (43.3%) but seems closely linked with the well-connected City Council and prominent NGOs.

The waste governance network inferred from Bristol's sample is structurally distinct from that of both Rotterdam and Cape Town (Figures 7, 9, and 11). In all three samples, the "other" nexus type features strongly. Indeed, in Rotterdam's case such institutions constitute 67.4% of the sample, 32.4% in Cape Town's, and 38.3% in Bristol's case. These seem to be versatile businesses and sometimes academic or purely discursive institutions. Some noteworthy anomalies emerge here. Bristol has significantly fewer identified institutions. Bristol also has the lowest maximum degree, and the highest average degree (see Table 5). It also has the highest graph density. Conversely, Cape Town has the highest maximum degree and the lowest average degree. There is very little difference between Cape Town and Rotterdam in terms of average degree and graph density. These two waste governance networks are similarly sized. But there are important qualitative differences between individual institutions and their effectiveness. Likewise, there are important contextual data which should be read alongside comparisons of the size, composition, and structure of the networks presented in this section (see, in particular, Table 7 for a compact comparison of relevant contextual factors such as population and rates of waste per city). Therefore, I analyse the qualitative attributes and circumstances of these three waste governance networks in Section 4.2 below before comparatively discussing integrated results in Chapter 5.

4.2 Qualitative analysis

For this section, I aimed to combine a variety of different qualitative sources to further explore the nature and context of the studied waste governance networks. Hence, I conducted interviews with key informants, appraised relevant government policies and accessible institution-specific financial statements, and analysed and appraised the online profiles of some institutions. I elaborate on this below. My SNA results provided an approximation of which institutions or agents would be most useful to analyse qualitatively. I conducted two direct interviews and two audio-visual analyses for Cape Town, four direct interviews and four audio-visual analyses for Bristol, and four direct interviews and two audio-visual analyses for Rotterdam. For each of the cities, basic details of the interviews are summarised in Table 6. Primary qualitative data drawn from workshops / audio-visual analyses are captured in Table 6 – with the relevant speakers having provided their consent to be cited as interviewees in my study. I collected and analysed qualitative data based on four themes. These were 1) biophysical, 2) social/cultural, 3) economic, and 4) political. I did not pursue the biophysical theme during interviews (see Tables 1 and 2), but rather appraised such city-specific characteristics with a desktop analysis of reports, online profiles, and texts. Results are thus complemented with reports, webpage content, and literature. The addition of such textual analyses was not done uniformly but was rather informed by the rate at which respective city-specific analyses seemed to reach a satisfactory level of data saturation.

I opted to appraise city-specific waste governance network characteristics by exploring the social, economic, and political themes during interviews (see Tables 1 and 2). The open, transdisciplinary approach I took to analysing the results below is explained in Section 3.4. But I do want to remind the reader that the manual approach I took to thematically analyse results in this section was anchored in the philosophical foundations of critical institutionalism as set out in Section 2.2.2 and, specifically in terms of the qualitative data analysis, in Section 3.4. To recap, my decision to deprioritise the biophysical theme in interviews stems from my critique of CE and FEW nexus in Sections 2.1.1 and 2.1.2. Further, my interdisciplinary combination of environmental governance theory (Section 2.2.1) and critical institutionalism theory (Section 2.2.2) reflect my critical analysis of the qualitative results emanating from the social, economic, and political question-themes (Tables 1 and 2). And, indeed, as I have alluded to in Section 3.4, the way my interview questions developed over the course of my research process (2019 to 2021) is a function of my analysis process in action. And, lastly, the selection of interviewee statements I present in this section (Section 4.2) reflects my reading of critical sociology with an emphasis on the problem of waste commodification; which I link to a broader critique of capitalist society in this research.

Reflecting on the process of qualitative data collection, one similarity across all cities was that academic stakeholders were interested in sharing their knowledge. Government representatives

in Cape Town and in Bristol were not directly accessible, whilst individual government representatives in Rotterdam were willing to share data and critically discuss it. In contrast, key business representatives in Rotterdam were unwilling to get involved in a critical inquiry into their domain. One interviewee suggested that there is a reputational struggle for recognition between businesses and government in the Rotterdam waste governance network (Interviewee D, 2021). Business representatives in Bristol and Cape Town only appeared willing to engage and share thoughts and data with the prospect of some potential benefit. Third sector representatives in Bristol were particularly willing to engage and several of them appeared to have well established, transparent relations with local businesses and academia. Networking in Cape Town was facilitated by often unstructured academic and third sector forums. However, prominent third sector representatives in Cape Town were reluctant or unavailable to engage in direct interviews.

Table 6: *Overview of interviewees. Some data is undisclosed for the purpose of confidentiality.*

Identifier	City	Sector	Date
A	Cape Town	NGO	Mar 2021
B	Cape Town	Government	Nov 2019
D	Rotterdam	Academia	Sept 2021
F	Rotterdam	Academia	Jul 2021
G	Rotterdam	Academia	Jun 2020
H	Rotterdam	Government	Jun 2020
C	Bristol	Academia	Mar 2021
E	Bristol	Business	Oct 2020
I	Bristol	NGO	Mar 2021
J	Bristol	Business	May 2021

4.2.1 Cape Town

In this section, I describe key institutions identified using SNA and critically analyse the role of CE and FEW nexus ideas in the formation and operation of the overall waste governance system. One of the key findings here is that local government is pivotal in Cape Town's waste governance.

One of the most well positioned nodes is GreenCape, which I describe below. Figure 8 shows

and Council for Scientific and Industrial Research (CSIR). These connections are making GreenCape a popular networking partner for nearby universities, colleges, and other academic organisations. Furthermore, GreenCape supports businesses, investors, and government at all levels to "*remove barriers to establishment and growth, and build a resilient green economy*" (GreenCape, 2021). GreenCape featured in or organised several national and regional seminars and panel discussions, placing this organisation at the centre of environmental governance

discourse in South Africa – and in the Western Cape (where Cape Town is located) in particular. Some of its main activities include supporting businesses ("*providing policy and regulatory advocacy and support, facilitating access to finance, facilitating market access, establishing skills development partnerships, networking, and information-sharing events*", etc.) as well as local, provincial, and national government ("*support on the development of standards, regulations, tools and policies, expert technical knowledge on key sectors in the green economy, and access to networks of key players across business, academia, and internationally*") (GreenCape, 2021).

GreenCape was established by the now Premier of the Western Cape Province, and essentially exists at the intersection of government and the third sector. In addition to this, the relative prominence of Municipal Bins and Recycling (Figure 8), a department of local government, attests to the local and provincial government's distinct self-identification as the hub of "green economy" style development in Africa. This kind of intensive self-identification at a local and provincial government level is unique in South Africa. A major activity in GreenCape is networking, and its Western Cape Industrial Symbiosis Programme (WISP), funded by the City of Cape Town itself, "*provides* [its] *business members with dedicated time and technical expertise, connecting companies with unused or residual resources such as materials, energy, water, assets, logistics, and expertise*" (GreenCape, 2020a). The WISP programme thus embodies both the CE and FEW nexus concepts in practice, but its internal workings and contractual arrangements are opaque. In telephone calls made between March and October 2020, repeated inquiries for access to an anonymised version of GreenCape's WISP database were denied on the basis of confidentiality agreements between GreenCape and its ultimately unidentifiable "member businesses". Accordingly, agreements between GreenCape and its WISP platform's participating businesses are contractually limiting access to information for third parties, including researchers.

The Solid Waste Network (SWN), a spinoff of the South African branch of Slum Dwellers

It is

> *throughout the Cape Town metropolitan area. The goal of the Cape Town recycling social enterprise model is to upscale to a national footprint, and has the real potential to achieve sustained impact as a livelihood programme* (SDI, 2012).

As shown in Figures 6 and 7, the SWN maintains a relationship with the City of Cape Town's Solid Waste Management Department. The latter sub-department of the City of Cape Town did not respond to repeated requests for engagement during data collection. The SWN is a small part

of a convoluted, large-scale network which does not appear to have dedicated representation, and it is unclear whether it still operates. Hence, it was impossible to contact SWN. However, there were rich secondary sources of data on the daily realities of informal waste pickers in South African cities (Perez, 2017; Samson, 2019). These portrayed a stark hierarchy of power, where government refuses to recognize the independent value of informal waste pickers. In some cases, organised waste governance and recycling institutions had allegedly abused informal waste pickers. At the same time, decision-makers at or near the top of the power hierarchy in Cape Town publicly state that their "green growth" agenda was inclusive by design – with the interests of unemployed and poor residents at its core. This alignment with principles of equity appeared to

Cape Town had been consistently outmatched by the combined productivity of the independent waste pickers. According to a study published by PlasticsSA, the umbrella body representing the entire value chain of the local plastics industry, 70.4% of recyclables came from landfills and other post-consumer sources in 2019 (Plastics SA, 2020). Most of this material was collected and transported by such informal waste pickers, who had no access to formal infrastructure or political-cultural capital, for little to no compensation (Perez, 2021; Plastics SA, 2020). To illustrate waste pickers' very low level of access to political-cultural capital, Perez (2021) argues informal waste collectors have the lowest influence on how waste policy is implemented whilst plastic producers have the highest – despite the latter benefitting most from the production of plastic waste to begin with and thus being responsible according to the "producer pays" principle. Formal waste governance institutions which claim to champion recycling and gain discursive power using pretences of equity should therefore be treated with scepticism in unequal contexts.

Municipal Bins and Recycling are widespread and accessible in Cape Town compared to other cities in South Africa, but these (local government controlled, but separately operated) facilities are mainly drop-off points where residents in the area can voluntarily dispose of unsorted or semi-sorted recyclable solid waste materials like plastics. Engagements with representatives did not yield any data regarding the quantity and types of waste that were processed at these centres, as representatives who declined interview requests deferred to senior, but unavailable, colleagues.

The Water Hub, as seen in Figure 8, is a registered NGO with a board of directors as its brokering or networking face. Interviewee A (2021) identified power struggles between agents from academia, government, business, and third sector as a consistent limitation. In commenting on the development (or lack thereof) of the Water Hub and the implementation of a CE in this area, Interviewee B (2019) – an official from Cape Town's neighbouring Stellenbosch Municipality, said that "*the entire structure of local government needs to be dismantled and reconfigured to*

achieve a real CE". Other barriers to the achievement of the Water Hub's research and development goals included a lack of buy-in from the highly fragmented local community, vandalism and theft, as well as funding constraints. More exogenous constraints included a lack of tangible support from the national Department of Water and Sanitation (there was, however, discursive support), which – according to Interviewee A (2021) – may be due to the political chasm between 1) the Democratic Alliance (political party) ruling the Western Cape, including Stellenbosch and Cape Town and 2) the African National Congress ruling the rest of South Africa.

In order to reflect upon the disposition of national government institutions on CEs, a Deputy Director General in South Africa's National Treasury (speaking at the National Research Foundation's SA-EU Strategic Partnership Dialogue Facility) said that there is ideological and in principle support for the CE, but "*politics is a real inhibitor of progressive fiscal mechanisms in favour of a green or circular economy*". Furthermore, "*one department cannot bring about a circular economy*" – there needs to be a multi-sectoral approach to the ideation and implementation of real CEs in South Africa. This, I argue, highlights the FEW nexus-CE overlap.

The CSIR, a subsidiary of national government's Department of Science and Technology (DSI), published an annual report on their ten-year Waste Research Development and Innovation Roadmap for South Africa (2015 – 2025) (DSI, 2014). In this, they emphasised the importance of their partnerships – and these included institutions such as "*various provincial green economy, innovation, and green skills forums*" as well as international entities such as the UN Industrial Development Organisation (UNIDO), International Solid Waste Association (ISWA), and the International Environmental Technology Centre (IETC). The report's annexures list some completed research programmes. Almost each of these categorically fall within a material-biophysical discourse of industrial and chemical innovation (CSIR, 2019).

In terms of national policy, the National Environmental Management Act 107 of 1998 and the associated Waste Act reflect principles of equity such as prioritising the prevention of pollution, placing the onus of implementation on the State (both national and local spheres) and businesses, and placing a universal *duty of care* on both consumers and producers. However, implementation of these provisions is rare. When asked about technological and financial factors in the governance of urban waste, Interviewee A (2021) said

…money is a key issue. … It's about how that is distributed and whether people get a fair share of that. … Do environmental and international development policies that are trying to control this make much difference? … I think it's too much in government's hands in this sense. … We see government disappearing from where private sector power lies … and we've created this incredible chasm that to me is massively problematic. … Government can't do it on its own, but

think they can, and they want to stay in power … this is the way they think they can do that. And they've done it badly.

Financial resources were thus highlighted as a major problem in the urban waste governance processes of Cape Town, whilst technology was not. Still, financial flows that were said to be essential for the implementation of CEs or FEW nexus concepts were described in a manner that suggested that they were inextricably interrelated with broader political dynamics in the South African context. Certain interviewees suggested that there is a lack of accountability for the human health and ecological consequences of poor waste governance which is dominated by local governments in Cape Town and neighbouring Stellenbosch. A public confrontation with scientifically verified pollution figures in the area's scarce water resources, for example, would jeopardise the profitable viticulture sector as well as rates that the City of Cape Town gets paid for its waste governance. The likelihood of such confrontation was compounded by "… *strong institutional distrust* [and the perception of] *an increasingly immature democracy and a growing, centralised power*" (Interviewee B, 2019).

In order to get a broad sense of whether and how the current arrangement or structure of institutions affects the trajectory of waste governance, Interviewee A (2021) said that "*running an* [innovative waste governance institution] *becomes a means of influencing and persuading governmental political power*", however, the question remained as to "*how to get these guys to actually wake up and recognise that there is something that should influence their decision-making*". Inclusiveness and inflows of effective scientific or expert opinion into mainstream decision-making processes around waste thus seemed limited. Interviewee B (2019) also raised a problematic short-termism:

Whether the municipal officials then have a budget and have the sanction of political will to carry out their work is a question that is deeply troubling to all these officials who know … that within five years, the whole local government structure is going to change… It could even be a new political party, which has a different agenda and all the things you worked at over the last five years may just crumble in moments.

It is perhaps both the prospect and absence of this radical structural transformation that repels experienced individuals and change agents from governmental waste governance institutions. Further, one of the most powerful instruments for institutional change could be something as simple as "*scientific discoveries revealing how devastating the continued existence of hazardous waste and pollution of … the water that is flowing into the Berg River, which irrigates 3 billion Rands* [approximately 190 million USD] *per year worth of* [wine] *exports. If the EU gets to know all of that, then I think they would ask the very, very serious questions*" (Interviewee A, 2021).

4.2.2 Bristol

The SNA results described in Section 4.1.2 suggest that a relatively wide variety of institutions plays a significant role in the waste governance network of Bristol. Indeed, some of the most prominently featured institutions appraised in the SNA specifically identify networking as a core feature of their operations.

One of those most prominently featured institutions is the Bristol Green Capital Partnership (BGCP). Its self-stated vision is "*a sustainable Bristol with a high quality of life for all*", which broadly entails "*a circular economy city, where organisations and citizens reject a throw-away society, reducing, re-using and recycling*", among other things (BGCP, 2021). This community interest company (or social enterprise) is governed by a board of directors consisting mainly of founding supporter members representing commercial, academic, and financial institutions. Specific entities represented at board level and captured in my SNA included Wessex Water, Sustrans, the University of Bristol, Bristol Chamber of Commerce & Initiative, Resource Futures, Centre for Sustainable Energy, and Triodos Bank. One board member represented a key NGO that also featured prominently in the SNA, namely the Bristol Food Network. The BGCP aims to achieve its vision by, inter alia,

> *enabling collaboration, information and skills-sharing, and collective action; showcasing innovation and best practice, and broadening the reach of environmental sustainability initiatives within and beyond Bristol; engaging with policymakers and decision-making processes to ensure city, regional and national frameworks support our shared vision* (BCGP, 2021).

Another institution which my SNA results suggest is relevant and influential in the Bristol waste governance network is the Bristol Waste Company. Categorised in the "food" category in terms of the FEW nexus concept, and indeed identified and included in my SNA (but not labelled in Figure 9, due to its relatively low connectivity), the Bristol Waste Company is wholly owned by Bristol City Council and is tasked with waste and recycling collections, including food waste. This entity acts as a go-between, linking the operations of Bristol City Council and GENeco (interviewees expressly identified GENeco as one of Bristol's most important waste governance institutions). All profits or surpluses generated by the Bristol Waste Company are reinvested into the city itself – with "*no interest in making a profit for non-Bristol shareholders*" (Bristol Waste Company, 2021). But this is not the case for its principal partner in the private sector, GENeco.

GENeco focuses on collecting food waste and reprocessing it into biogas and soil improver (it is, in turn, a for-profit subsidiary of Wessex Water). According to its 2019 annual report and financial statements, GENeco generated a profit of £339k for the financial year as at 30 June 2019. In turn,

its parent company – Wessex Water – generated a profit of £212.5million according to its self-stated Annual Results 2020. GENeco invites locals to "*be part of the zero waste revolution*" wherein it inclusively champions a proudly local "*circular economy in action*" (GENeco, 2021).

Bristol Energy's website "mission" page's heading reads (in bold font) "*a force for social good*" and the page contents describe a sizeable reinvestment of profits into local urban development initiatives. This "*social good*", which has been returned to the institution's founding city, is quantified: £12million to date (Bristol Energy, 2021). Bristol Energy generated a profit of £5.6million for the financial year ending on 31 March 2019. At the same time, it explicitly promotes energy saving in households and other points of use. Such promotion is an imperative imposed by legal obligations under national government's Energy Company Obligation scheme, which applies to all those energy suppliers beyond a certain electricity generation threshold in the UK (Ofgem, 2021b). However, in early 2022, Bristol Energy ceased its operations and went under administration. Since then, Ofgem has determined that its customers will move to British Gas.

Ofgem is the regulator for the gas and electricity markets in the United Kingdom. It is the institution responsible for ensuring that certain energy sector development targets are met. Historically, former public electricity suppliers (PES) had been obligated to purchase electricity from renewable generators. To satisfy this requirement, "*PES set up the Non-Fossil Purchasing Agency (NFPA) in 1990 as their agent*". This entity and its Scottish equivalent persist today, but the so-called Non-Fossil Fuel Obligation has since been replaced by the Energy Company Obligation scheme and, more particularly, the Renewables Obligation as government's primary instruments of renewable energy and environmental protection policy in this sector (Ofgem, 2021a). Around December 1990, the UK energy sector markedly transformed from a public sector dominated sphere to a highly privatised one – with the result of competitive value propositions available to customers. Interviewee C (2021) points to this trend around waste, saying "*obviously, there are a lot of commercial enterprises involved in waste management, but the City Council has tried to coordinate that and has its own Bristol Waste Company which is extremely important*".

To elaborate further on the legislative environment affecting waste governance in Bristol, we can consider UK waste governance policy more generally. Since 2000, change has been the only constant in this policy regime with significant Europeanisation seen in the laws that govern how waste is produced and disposed of here – primarily as a result of European Union waste laws whose future in the UK context are unpredictable post-Brexit. This was interestingly the period during which data collection for this research was carried out. Burns et al. (2019: p. 286) suggested that sustained political activity and pressure from "*the UK's vibrant* [environmental non-governmental organisations] *sector and deep-seated public support for protecting the*

environment will be crucial in determining the strength of post-Brexit environmental governance arrangements".

The most recent and relevant overarching policy on waste governance in Bristol's national context was the Resources and Waste Strategy (DEFRA, 2018), which set out "*how* [to] *preserve* [England's] *stock of material resources by minimising waste, promoting resource efficiency, and moving towards a circular economy*". However, in a study focused on this strategy's approach to food waste, Bradshaw (2020: p. 1) argued that "*policy-makers have framed food waste as a consumer behaviour problem, rather than a structural challenge*". Bradshaw (2020: pp. 1 & 19) suggests that a departure from economic growth narratives, combined with promises of government action, obscure "*ongoing reluctance to intervene against powerful interests*" and "*the causes (not symptoms) of food waste*". Rather than tackling overproduction (and the political and economic interests that benefit from this problem), the Resources and Waste Strategy rather "*shifts the burden of redistributing food away from the state and retailers, on to farmers and charities*" (Bradshaw, 2020, p. 1). In this context, the Bristolian waste governance network comprises a significant number of institutions that consider food waste as a part of their portfolio. For example, the Bristol Food Network (Bristol Food Network, 2023). The UK is widely considered to be a leader in food waste governance. This brings the food-to-energy industry into focus. There are challenges around the food-energy waste nexus where, for example, the large-scale deployment of anaerobic digesters could adversely impact on the availability of surplus food for people living in acute poverty (Michalec, 2020).

The stated perception among interviewees that the UK Government is reluctant to disrupt established power hierarchies and modes of production is important to note (Interviewees C & I, 2021). This transcends the realm of waste governance per se and is rather speaking to the mechanisms through which policymakers attempt to focus on the structures and processes responsible for the production and reduction of waste. In turn, this reflects paradigmatic attributes of national regimes. Nonetheless, it is worth noting that the Department of Environment, Food, and Agriculture's (DEFRA) broader policy position culminating in the Waste Management Plan for England (DEFRA, 2021a), was drafted through inclusive processes (DEFRA, 2021b). That is, it encompassed a thorough and well documented public consultation process whose outcomes were easily accessible. The Resources and Waste Management Strategy was not a sequel to the Waste Management Plan but did hint at where future policy may be moving towards. A few noteworthy principles that underpin the overall policy environment mentioned here are the "waste hierarchy" (prevention and preparation for reuse and recycling: first priority), diversion of waste from landfills, financial [dis]incentives for consumers (*e.g.*, plastic bag levy), producer pays (the

Producer Responsibility Obligation Regulations 2007 compel businesses and industries to recover and recycle a certain amount of packaging materials), and general principles of "shared responsibility" (DEFRA, 2011).

Interviewees representing energy and food related institutions in Bristol emphasised their dissatisfaction with existing legislation in 2019, with Interviewee E (2020), for example, saying rather plainly that "*collaboration, policy, and lobbying*" had become a key part of their work – as opposed to material-biophysical operations. Representatives of food related institutions were aligned in their criticism of political and economic domination in the city and beyond; labelling the Resource and Waste Management Strategy for England as a wish list which was still "*under consultation*" and was flawed in its reliance on "*voluntary behaviour change*". They contrast this approach to stronger measures taken by the Scottish Government, where the separation of food waste from general waste was already compulsory for commercial institutions. In contrast, water sector players had better established infrastructure and benefitted from a self-regulated market.

Big efforts have been made to make it as easy as possible for people in distressed economic circumstances to forego payment ... they have statutory requirements that they have to abide by. Food companies, if it makes good [public relations] *and it makes sense economically, get rid of stuff they can't do anything with anyway. So, as long as it fits into that sort of "well, there's not really much of an effort, it's not a huge cost for us to do it", then these things actually happen* (Interviewee I, 2021).

When asked whether the policy environment should change to improve waste governance and its social outcomes in particular, all interviewees responded affirmatively; with varying suggestions that certain aspects should be tightened or controlled, *i.e.*, they should be moving away from voluntary policy mechanisms and data sharing principles toward more mandatory measures, and – at the same time – that some restrictive policy mechanisms should be deregulated to allow innovative recycling and re-usage.

Looking at the food waste issues, I think the commercial food waste problem does require a lot more legislation. But also [it requires] *looking at* [regulation versus deregulation of food waste] *in terms of the health and safety requirements around the legislation that's there now and where there's potential for relaxation of regulation to enable better recycling and better usage of the waste materials. So, it's complex* (Interviewee I, 2021).

Interviews confirmed my SNA results insofar as the dominant relationship in Bristol's waste governance network is between the City Council and the business sector, to which many of the City Council's functions are outsourced. Most notably, Bristol City Council is contractually

bound to GENeco through its Bristol Waste Company – a relationship which has seen major improvements in the amount of food waste being recycled. Interviewees indicated that financial resources flow from taxpayers to City Council to businesses such as GENeco and the Bristol Waste Company. "*"Follow the money" is often the best way to determine where the power lies*" (Interviewee I, 2021). Based on this statement, power in Bristol's waste governance network originates with taxpayers, is transferred to Bristol City Council, and finally on to businesses such as the Bristol Waste Company and GENeco. In a system that appears to be heavily reliant on a free-market policy regime, factors of competition and sunk costs can also inhibit mainstreaming alternative institutions. Referring to disruption in the energy sector, and potential displacement of dominant institutions, "*that would mean that the investment that GENeco put into its bio-digesters can become redundant … So, expect a great deal of resistance to that*" (Interviewee I, 2021).

But there appeared to be strong elements of individuality (in terms of skills and wealth) and third sector activism which interact with the national free-market policy environment, culminating in affirmative waste governance discourse. Pointing to social factors relevant for such affirmative discourses about urban waste governance in Bristol specifically, Interviewee J (2021) said

> *…they had these sort of key, you might call them anchor, NGOs that have grown up in Bristol. As to why … apart from really accomplished former engineers and architects, it also has … relative wealth – loads of poverty as well – but you've got this relative wealth. Then* [there is] *this quite alternative mentality …* [and] *a vibrant anti-establishment cultural scene going on.*

Distinct individual capacity was not seen as a hindrance to affirmative discourse about waste governance in Bristol in Interviewee J's (2021) perspective, but an enabler of it. Further, it was suggested that one of the major contributing factors in Bristol's "sustainable city" status was individual excellence and the application of individual expertise by means of institutionalisation.

4.2.3 Rotterdam

Rotterdam hosts an expansive and clustered network of waste related institutions that appear to be primarily entrepreneurial. However, the high degree of clustering in Rotterdam's institutional network (Section 4.1.3; Figures 11 & 12) indicates that some closer analysis of relationships is especially necessary to avoid qualitative interpretations that are based on network structure and metrics alone. Discourse around Rotterdam waste governance includes descriptions of a highly capable waste governance network, with comparatively little overt focus on the social-political dimension of waste governance. To illustrate this further, the causal relation between institutional capacity and high levels of "between group" connectivity comes into question when we see that clusters in this network consist of largely the same institution-type. *E.g.*, virtually all institutions associated with the Dutch Waste Management Association appear to be businesses (Figure 12).

This begs the question: does institutional diversity imbue network members with more capacity, as opposed to a generic, quantitative measure of how well connected the average institution is? I reflect on this question with reference to results from all methods used in my study in Chapter 5.

Circle Economy and Blue City are two noteworthy institutions which feature prominently in Rotterdam's network and seem to champion the FEW nexus and CE concepts. Circle Economy's mission is to "*connect and empower a global community to create the conditions for systemic transformation*" by offering businesses, governments, and cities "*holistic and integrated approaches*" towards creating systemic change and strategies (Circle Economy, 2021). Circle Economy is an explicitly not-for-profit institution, and its reach goes beyond the boundaries of Rotterdam, encompassing Amsterdam and other cities around the world (Circle Economy, 2021).

Blue City is "*an independent platform* [or incubator] *for the City of Rotterdam, its entrepreneurs, and its inhabitants*". Its stated intention is to connect small start-ups (entrepreneurs) with big companies to scale up their innovations. It

> *shows what is possible at a local level and what the counterforces are, e.g., legally and fiscally … works with local products, believes in cooperation instead of competition, and creates endless circles of value … not only develops networks,* [but] *links them together towards an interwoven and unbreakable ecosystem* (Blue City, 2021).

Although Circle Economy is categorised as an NGO in my SNA (see Figure 12), both this organisation and Blue City are waste governance network hubs that seem to be mainly connected to businesses (often small-scale start-ups) – as their websites clearly indicate. However, there are individual exceptions. Commenting on the correlation between Blue City's institutional values portrayed on its website and the experience of trying to collaborate without any prospect of financial gain, Interviewee F (2019) said that

> … [Their] *values and principles resonate very closely with certain projects – and that is likely why they manage to secure funding, but they have not been willing to collaborate and share data.* [Blue City seems to be focusing their activities on] *deinstitutionalisation of a business as usual linear economy … When the regulatory environment starts dis-incentivising waste, incumbent companies become vulnerable and willing to absorb and collaborate with innovative projects*.

The same interviewee pointed to some competition between the Ministry of Infrastructure and Environment's representatives and Blue City Lab's leaders for recognition as champions of Rotterdam's vibrant CE-style waste governance system. At the city scale, as Figure 12 suggests, local government (Gemeente Rotterdam) appears to play a relatively negligible role in the waste

governance network – only displaying patent connections with the provincial government (Provincie Zuid Holland) and the Dutch Waste Companies Association. Still, the aforementioned interviewee's indication that there seems to be competition between representatives of a national organ of state and representatives of Blue City for public recognition is perhaps reflected by the "distance" between the Netherlands Organisation for Applied Scientific Research (TNO) and the academic institutions clustered around Blue City, as well as the apparent lack of such direct association between said academic institutions and provincial / local government (see Figure 12).

With reference to processes of institutional change to a CE in The Netherlands, an academic interviewee said that even though there is "*broad recognition that the linear economy is under pressure, it is difficult to break through the dominant system. There* [are] *lots of activities going on to build-up or accelerate new economic activities … but phase-out of* [undesirable] *policy only finds a small place on the agenda*" (Interviewee G, 2020). This expression of concern that the process of institutional change to a CE-style waste governance network in Rotterdam, and The Netherlands more broadly, is not adequately decommissioning "linear" infrastructure and practices went further, suggesting that "*circularity is struggling to get past recycling. Destabilisation becomes somewhat visible, but hardly any real chaos*" (Interviewee G, 2020). The Government of The Netherlands' role came into question throughout this interview. Most notably, Interviewee G (2020) was uncertain about whether such an institution could bring about the chaos that they saw as a prerequisite to bring about more fundamental and liberatory change.

Shedding light on precisely how decision-making takes place through projects and "dilemmas" around the CE principles which apparently characterise Dutch waste governance, a senior figure (referred to here as Interviewee H) in government offered some useful observations and insights. Interviewee H (2020) described their department as "*reliable, hierarchical, risk averse, arrogant, and focused on availability and safety*". It takes an unapologetically competitive approach by "*stimulating and rewarding frontrunners with relative advantage and engaging the majority through minimum requirements*". This is purportedly how the nation-wide strategic goal, set in 2016 for the government department in question (undisclosed for purposes of confidentiality and anonymity) to "work in a circular way" by 2030 and to become completely circular by 2050, would be achieved. Interviewee H (2020) spoke critically about a cooperative approach, wherein

> *…trade-offs mean compromises and new types of dependence and cooperation. Learning will increase if data and insights are broadly shared, but what about competitive advantage? There are some dilemmas like: do we focus on incremental changes that are doable, and can be used in current projects, or rather systemic changes? We are mainly implementing technical circular*

solutions in a linear system, rather than transitioning to a "circular economy". Do we focus on reusing existing structures or realising new ones in a fully circular way?

Interviewee H (2020) also volunteered comments on political and fiscal factors at play in the process of institutional change. A challenging next step to more radical change was "*saying goodbye to certain types of typical linear industry or partners. Also, should we allow for mistakes and failed experiments if we learn a lot from them?*" This idea of welcoming and learning from failure stood out in the interview. There was a noteworthy trace of willingness to engage on topics that are politically sensitive. For example, the potential importance of fiscal policy reform, as in "*changing the structure of for instance the financial system* [by] *taxing materials more and labour less or invest more in data collection and infrastructure maintenance*" (Interviewee H, 2020). Interviewee D (2021) focused on the social factors in the City of Rotterdam, highlighting its entrepreneurial and technical strengths, but also emphasised a problematic tension that arose between relatively high levels of voluntary waste recycling by households and existing, committed contracts which bind local government to provide fixed volumes of waste to profit-oriented waste governance institutions:

> *Rotterdam is a place where people are very innovative, very independent, and very entrepreneurial … it is really, I guess, compared to other countries, a place where people can be entrepreneurial at lower costs or lower risk.* [Local government] *has contracts with waste plants outside of the city. They committed to a contract 10 years ago or something, giving them X amount of waste per year. So that's why in a lot of places you don't see separated recycling, because people are separating too well, basically. That doesn't give the city enough waste to sell or give to the waste incineration plants to create energy and stuff* (Interviewee D, 2021).

However, within the boundaries of an entrepreneurial paradigm, there were some suggestions that the policy regime was indeed conducive to disruption and innovation. For example, "*there's not so much inertia from existing business … to have them connected somehow, it could be through a platform like Blue City where they can reach … bigger organisations*" (Interviewee D, 2021). Financial independence was raised as a major imperative in Rotterdam. Reflecting on access to financial support from local government, Interviewee D (2021) said "*I don't think you* [should] *accept financial support from governmental or bigger institutions. If you want to be 100% certain that you maintain independence in your business model … self-fund*". Some social enterprises focused on poverty and inequity had been operating in Rotterdam (none specifically identified in my SNA or during interviews), and such institutions "*make it very well known that they're one of these companies that has* [social concern] *as a value*". A key cultural factor which interviewees identified was a willingness to critique imperfections and offer viable (albeit technical) solutions.

4.2.4 Comparative overview

The sheer complexity of the phenomena under study means that drawing concrete conclusions about directional causality is difficult. Nonetheless, insightful patterns emerged in the combined results of interviews, workshops, and textual analyses. The challenge of waste governance, covering all FEW nexus types and CEs, was clearly understood by most interviewees in Bristol and Rotterdam as an opportunistic space dominated by businesses, whilst it was predominantly understood as a public burden that was being dominated by local and provincial government in Cape Town. Bristol (explicitly) and Rotterdam (implicitly) were described as predominantly hosting "*relative wealth*" with some "*poverty as well*" (Interviewee J, 2021), whilst the majority of Cape Town's large population comprised impoverished people on average and hosts a waste governance network predominantly comprising acutely impoverished waste pickers who struggle with an authoritative local government (Perez, 2017). Economic inequality and the distribution of money was identified as a key factor in literature and interviews about the Cape Town waste governance system (Interviewee A, 2021), whilst this aspect was almost entirely absent in interviews with Rotterdam's representatives – and it featured relatively tangentially in interviews with Bristolian representatives. The interviews with Rotterdam representatives were such that imaginaries of future scenarios were expressed in mostly formalistic terms, whilst more radically alternative and unconventional imaginaries were expressed often by Bristolians. Furthermore, discourse on waste governance in Cape Town mainly revolved around the political-economic causes of failure to meet challenges, rather than a focus on the CE and FEW nexus axioms.

Table 7: *Attributes showing similarities and differences between cities under study.*

* per annum (GreenCape, 2020b), (Gemeente Rotterdam, 2020), (Bristol Open Data, 2017)
** per annum (MacroTrends, 2022)

As per Table 7, per capita rates of waste production were not markedly dissimilar between these three cities. However, there was an assumed dissimilarity between the socioeconomic statuses of their average residents. This is relevant since, for example, an average per capita rate of waste is

less meaningful in Cape Town where there is a high level of inequality. That is, one may expect large differences in the amount of waste produced by rich and poor households. On the other hand, the seemingly more equitable socioeconomic fabric of Rotterdam, comprising a relatively wealthy and substantive middle class, consists of environmentally conscious residents who can perhaps afford to voluntarily adjust consumption practices and recycle waste at household source. Valenzuela-Levi (2019), in asking whether the rich recycle more, finds that there are correlations between income and recycling and that this may be due to the distribution and relative quality of service provision (and its funding arrangements) rather than status-related behavioural choices.

Population size, growth rates and revenue growth rates also matter. In Bristol and Rotterdam, population figures were small and stable and average households were able (and required) to pay ordinary municipal taxes and levies for waste governance services, whereas in Cape Town this was not necessarily the case. Indigent households were exempt from such expenses in light of their relative inability to pay. This directly impacted on the capacity of, and need for, local and provincial government to directly undertake basic and advanced forms of waste governance. It may be that this plays an important role in the observed difference between private sector prominences in the waste governance network for each respective city. In other words, an affluent Rotterdam local government does not have substantive incentives to maintain its dominance by avoiding decentralised waste governance. It enjoys sufficient inflows of capital from an aligned national government (despite political divides). This did not seem to be the case in Bristol or Cape Town, where local political discourses diverged sharply from that at national level. In these cities, intergovernmental fiscal relations were tenuous and therefore each local government was actively asserting itself, either directly through individual representatives or indirectly through vicarious representation in third sector or business institutions, in a wide variety of waste governance undertakings which may garner political, social, and economic momentum and capital over time. I compare the presence and potential impact of different discourses across the cities in Chapter 5.

4.3 Agent based modelling

The agent based modelling results presented in this section bring a forward-looking and dynamic dimension to the results obtained from both my SNA and qualitative analysis. As explained in Sections 3.5 and 3.6, the design of the model used to produce the results I present below is largely informed by SNA and qualitative analysis results. In sum, this section starts with a presentation of generic model dynamics generated by running a random Scenario Setting with systematically variable Model Settings. The rationale for a wide range of interrelated Model Settings (parameters) follows from principles of interdependence and relational power in contemporary governance (Rhodes, 1997; Kooiman, 1999). The need for sensitivity analyses as in Section 4.3.1, which demonstrate the dynamics of my model design, stems from my alignment with principles

of indeterminism and stochasticity also applied in my abductive-retroductive approach to systematise my qualitative analysis in Section 3.4 (Tikly, 2015; Stutchbury, 2022). Themes of connectivity or attachment in my parameters stem from my first sub-hypothesis and contemporary governance theory. Elements of institutional change (such as disruption, stability, expansion, and elimination) stem from my reading of critical institutionalism theory. The model *grows* waste governance networks (Barabasi & Albert, 1999). In Section 4.3.2 to 4.3.4, I present city-specific results obtained from simulations that were iteratively run to grow waste governance networks that are compositionally and structurally akin to those observed using SNA. In Section 4.3.5, I compare city-specific results in terms of relative configurations of parameters to close the chapter.

4.3.1 Model dynamics

This section presents results obtained from a set of simulations that were designed to demonstrate the relative weight of each of the Model Settings / parameters outlined in Table 4 (Section 3.5). The significance of each parameter is demonstrated by a systematic simulation series testing the influence it has on the three network metrics reported by my model, namely i) total agents, ii) average degree, and iii) maximum degree. Selecting these network metrics allows for consistency with the network metrics I measured for each city in my SNA, and thus enables the triangulation of these different data sources. But I also selected these network metrics for the following reasons:

i) The number of total agents at the end of each individual simulation is meaningful because I configured the model to stop each simulation run when full figurative waste handling capacity is reached. It is at this moment of artificial stasis that the total agents metric was measured for each simulation. Scenario Settings (Table 4; p.73) were constant throughout this simulation series; parameters (Table 4) were the only variable factors determining the emergence of structure and composition in the waste governance networks "handling waste". The number of total agents thus reflects the average institution's capacity as well as the overall network's size, which may well be counteractive to individual capacity.

ii) The average degree – or the average number of connections each institution or node in the network has – is meaningful because it reflects the overall connectivity of the network. If we assume that, for example, institutions in the network gain financially as a result of building relationships in the waste governance network, then a higher average degree may be conducive to wider distribution of benefits resulting from networking activity.

iii) The maximum degree – or the number of connections the most connected institution (or node) has in each network – is meaningful because it indicates the extent of "preferential attachment" to dominant institutions. Further, when analysed in conjunction with the total number of agents and the average degree we can make inferences about waste governance networks' capacity to address social-environmental challenges, and critically assess my

hypothetical assumptions determining, and determined by, the model design. Measuring this metric as a function of factors extrapolated from the structural attributes of, and role of ideational power in, urban waste governance networks I observed using SNA and qualitative analysis, as per Chapter 3, also serves to integrate my mixed method approach.

This ABM approach is particularly suited to explore and explain how and why urban waste governance networks grow in certain ways. These networks, or systems, are complex and the cross-sectoral nature of their operations (especially considering how CE and FEW nexus ideas are shaping and re-shaping them) means that they are dynamic. ABM is a nuanced tool suited to this subject matter. Epstein (1999) argued that ABM is a generative tool that is highly suited to interdisciplinary inquiries whilst potentially facilitating empirical research beyond the boundaries of inductive and deductive reasoning. As I argued in Sections 3.5 and 3.6, my ABM design aligns with the abductive-retroductive approach – whereby I seek to explore and explain *potential* causes and effects of phenomena of interest. Again, there is conceptual confluence in the application of ABM to urban waste governance systems and their dynamics in the philosophical context of critical realism. Said philosophy foregrounds the intertwined emergence of structure and agency in the perpetual reproduction and transformation of social systems (Whaley, 2018). The system of interest in this thesis is urban waste governance, and I bring a focus on equity in investigating this system. The purpose here is to synthesise and simulate factors affecting the outcomes of institutionalisation or institutional change aligned with circular economy or food-energy-water nexus discourse in different urban waste governance systems. My model enables the explanatory "generation" of the targeted urban waste governance systems in this study, but it also enables an exploration of what factors may affect the form and functionality of such systems more generally. I elaborate on how my research design and frameworks directly informed my model design below.

The main reason for exploring the "relative weight" of parameters (factors) is because my model is designed to simulate a highly complex system with unpredictably interdependent parameters (an almost infinite range of Model Setting combinations interacting with an almost infinite range of possible Scenario Setting combinations, with three specific metrics being reported). It is important to first understand the effects of each Model Setting to be able to then meaningfully calibrate the three simulation series to re-create three networks with metrics similar to those measured for each research site, each with a unique combination of Scenario Settings representing each of the research sites on the basis of my SNA results. Testing the model dynamics with a constant set of Scenario Settings in a systematic way produces some transparency and prevents

any distorted results emanating from the inherent bias of a specific model design (Section 3.5.1). In other words, it makes my assumptions underpinning the model explicit and open for scrutiny.

Once the weighting of specific parameters was understood, this understanding informed my calibration or configuration of the model to "grow" or reproduce networks with metrics that closely matched observed networks under study – demonstrating specific combinations of Model Settings and Scenario Settings conducive to a consistently close match with observed networks. The precise procedure I used to explore the relative weighting of parameters involved a random but constant Scenario Setting configuration which I considered to be generally plausible and potentially realistic (food-waste = 37; water-waste = 32; energy-waste = 40; other-waste = 59; %-government = 30; %-business = 30; %-NGO = 20; %-academic = 10; %-financial = 10). With this, I ran a simulation series wherein each individual parameter was varied from absolute minimum to its absolute maximum in ten increments. The Netlogo BehaviorSpace tool I utilised is such that 0 is also included in the simulation set, meaning 11 runs in total. I did this twice for each parameter, with all other parameters set at i) mid-low, and ii) mid-high (that is, ParamSet 1 and ParamSet 2, respectively). The reason for doing this is the stochasticity of the model – which means that the interactivity of respective parameters is so unpredictable and potentially random that it is necessary to test increments of each parameter in two configurations wherein i) all other parameters are relatively inactive, and ii) all other parameters are relatively active. Thus, the interplays of random parameter combinations could be demonstrated. The distinction between two "ParamSets" also serves to minimise the weighting error by illustrating whether and how parameters effect reported network metrics differently in distinct configurations. That is, as demonstrated in Sections 4.3.1.1 to 4.3.1.9, individual parameters may have negligible effects in ParamSet 1 whilst they are having considerable effects on the reported metrics in ParamSet2.

Mid-low means the Model Setting (parameter) is set at 33% of its absolute maximum, and mid-high means the parameter is set at 66% of its absolute maximum. I ran each increment of each parameter 25 times (because the simulation process is stochastic, and therefore involves some randomness/unpredictability, and therefore requires rigour) – which resulted in a total of 550 individual simulations for each parameter, and 4400 individual simulations overall. Connecting this ABM modelling step to my SNA results, each city required different Scenario Settings (Table 4) in order to accurately reflect my city-specific SNA results (which were presented above in Chapter 4.1). I provide those results in the next section (Section 4.3.2-5). In the sequential formula I present below, I summarise my step-by-step calculation, as described textually above, for procedural clarity and rigour:

i) Each parameter is run at 10 increments, including 0:
(1 x 10) + 1 = 11 simulations.

ii) Each increment run 25 times:
25 x 11 = 275 simulations.

iii) Two cycles for each parameter (with others at i) mid-low, and ii) mid-high):
275 x 2 = 550 simulations.

iv) Eight parameters go through the sequence:
550 x 8 = **4400 simulations in total**.

Table 8: *Parameters for ParamSet 1 and ParamSet 2, excluding the variable Model Setting used in each simulation series.*

Model Setting	ParamSet 1 (mid-low)	ParamSet 2 (mid-high)
attachment-affinity	33	66
attachment-expansion	33	66
attachment-stability	33	66
disruptor-probability	33	66
elimination-probability	33	66
attachment-idolization [e]	1[e]	2[e]
capacity-link-influence [e]	1[e]	2[e]
elimination-exponent [e]	1[e]	2[e]

[e] exponential functions (whereas all parameters without an [e] are probabilistic functions)

Specifically, **capacity-link-influence** resonates with my research problem: *i.e.*, relational power in waste governance networks is pursued by means of a process of discursive consolidation (Koch et al., 2021), and it reflects the CE and FEW nexus ideas in that value is created through circular supply chain linkages. **Attachment-expansion** embodies my third sub-hypothesis and represents Barabasi & Albert's (1999) compelling argument: preferential attachment matters for real networks. **Attachment-stability** represents a factor of institutional work (to maintain status quos) and thus pursuits of domination (Beunen & Patterson, 2019). **Elimination-probability** and its opposite **disruptor-probability** reflect my second sub-hypothesis: material-technological-biophysical factors *and* ideational power are active in urban waste governance institutionalisation. **Attachment-affinity** is my synthesis of Barabasi & Albert's (1999) argument about preferential attachment and the gist of the FEW *nexus* idea. Pivotal to my ABM method design, **attachment-idolization** is an exponential function which stemmed from my reading of Barabasi & Albert's (1999) theory of preferential attachment and growth as two key factors in real networks. And, finally, **elimination-exponent** is an exponential function stemming from my reading of critical institutionalism, *i.e.*, it represents dominant institutions' active resistance to change (Vira, 1997).

4.3.1.1 Attachment-affinity

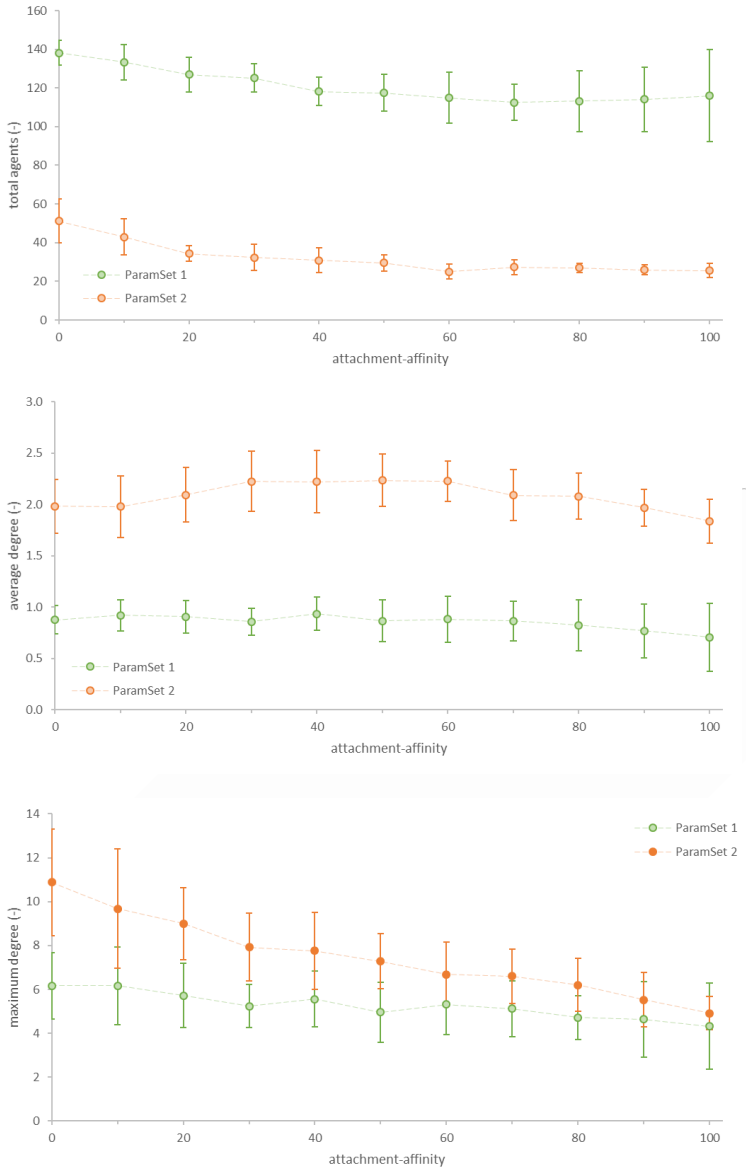


Figure 13: *Model output sensitivity to attachment-affinity parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

Neither average degree nor total agents are particularly sensitive to the attachment-affinity parameter for either ParamSet 1 or ParamSet 2 (Figure 13, middle and top). This means that, in this model, the average connectedness of institutions does not correlate with the probability of preferential linking with others of the same nexus-type; and the total number of agents also depends on the probability of preferential linking with others of the same nexus-type. Maximum degree decreases as attachment-affinity increases (Figure 13, bottom). Therefore, the connectedness of the most connected agent indirectly correlates with the probability of insular linking. This indirect correlation is more pronounced in ParamSet 2.

4.3.1.2 Attachment-idolization

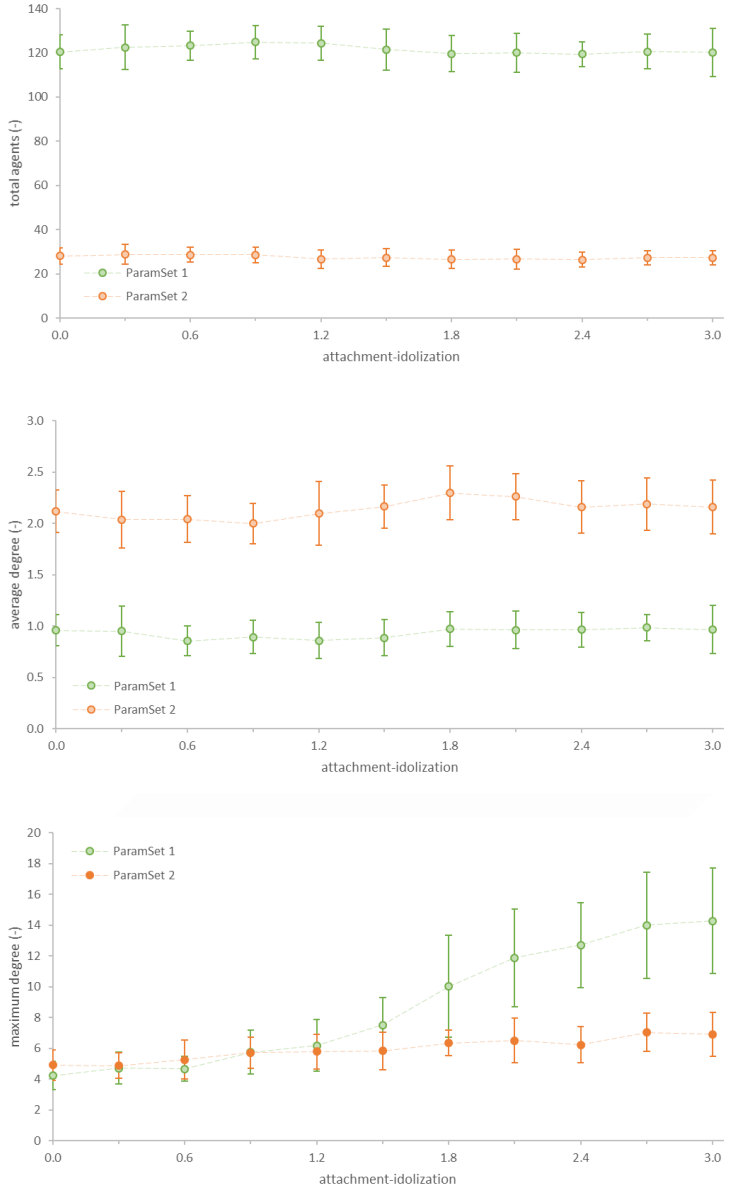


Figure 14: *Model output sensitivity to attachment-idolization parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

Neither average degree nor total agents are particularly sensitive to variations in the attachment-idolization parameter (Figure 14, middle and top). This means that, in my model design, neither the total number of agents in the network nor the average connectedness of these agents correlates with the probability that agents preferentially link with other agents that are more well-connected. However, the maximum degree (number of connections the most connected institution has) increases as attachment-idolization increases. Therefore, the maximum degree directly correlates with the network-wide probability of preferential relations with dominant institutions (Figure 14, bottom). This is more pronounced in the mid-low model setting of ParamSet 1.

4.3.1.3 Capacity-link-influence

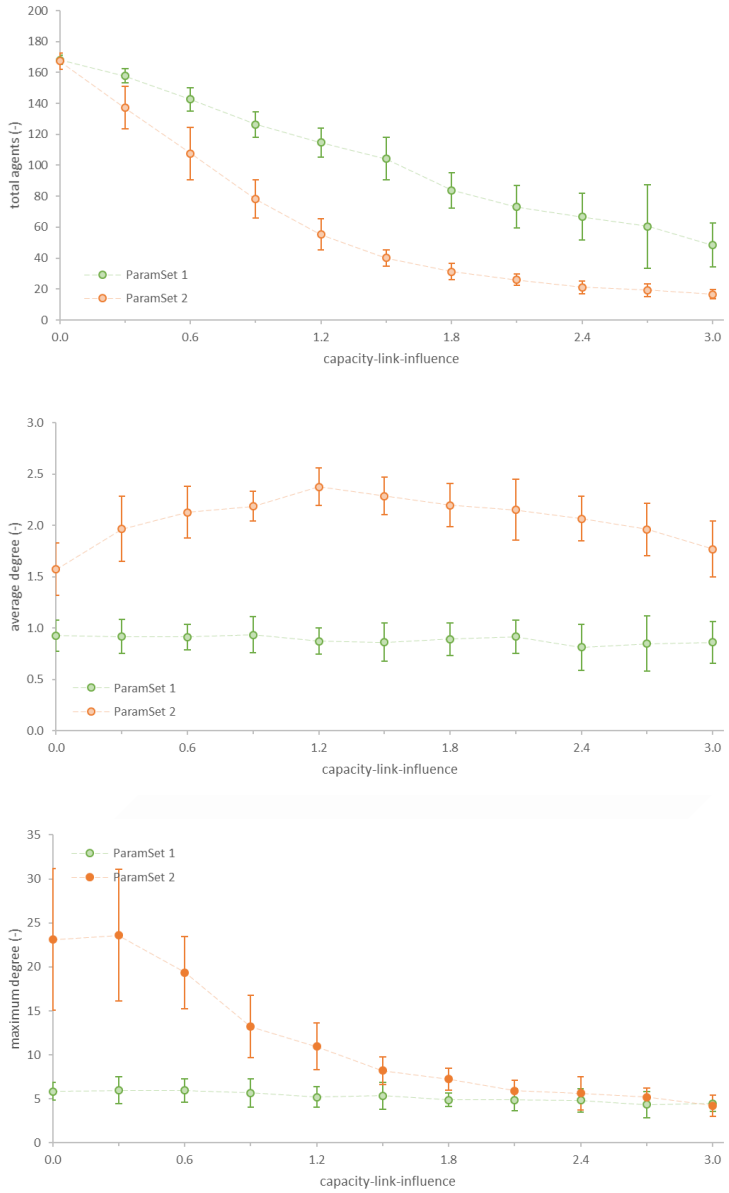


Figure 15: *Model output sensitivity to capacity-link-influence parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

The number of total agents decreases as capacity-link-influence increases (Figure 15, top). This means there is an indirectly correlating relationship between capacity-link-influence and the number of institutions involved. Average degree is relatively insensitive to this model setting. And the average degree is lowest when capacity-link-influence is at its minimum and maximum settings in ParamSet 2 (Figure 15, middle). Also, in ParamSet 2, the maximum degree is highest when capacity-link-influence is at its minimum (Figure 15, bottom). This means, there is a non-linear, indirectly correlating relationship between maximum degree and capacity-link-influence. The more linked the most linked institution is, the less links matter for waste handling capacity.

4.3.1.4 Attachment-expansion

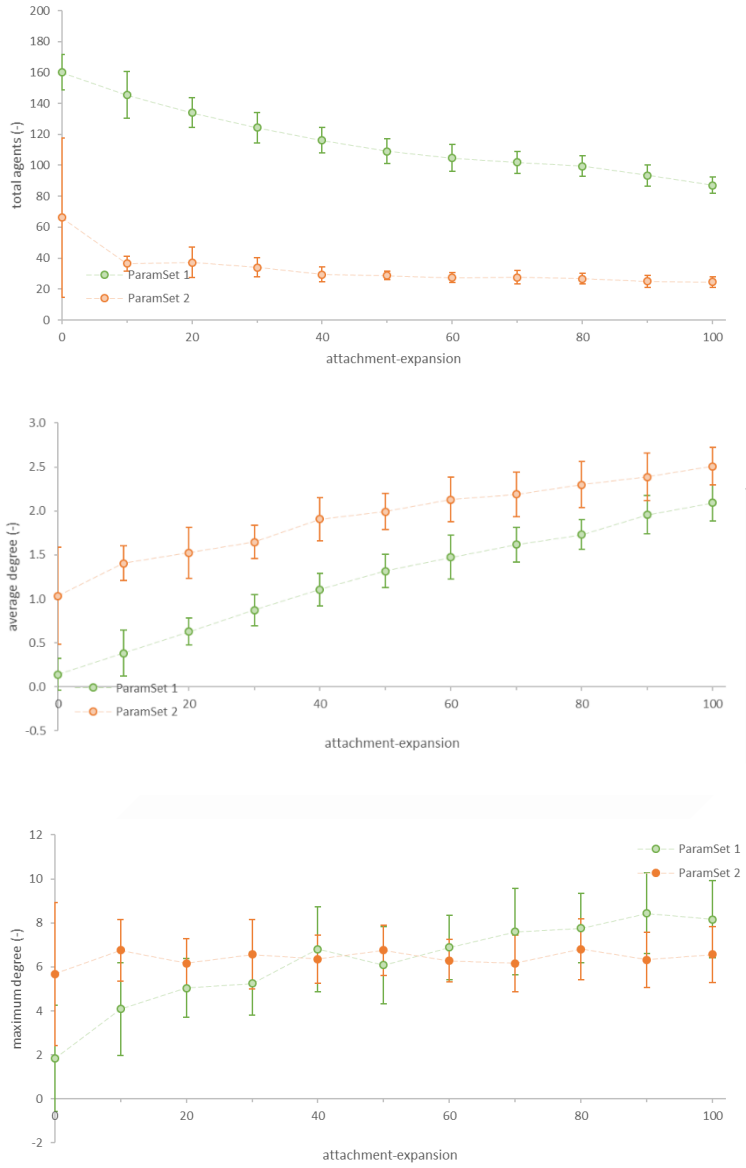


Figure 16: *Model output sensitivity to attachment-expansion parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

In both ParamSet 1 and ParamSet 2 (but more so in the former), the total number of agents decreases as attachment-expansion parameter increases (Figure 16, top). This illustrates that there is an indirectly correlating relationship between total agents and attachment-expansion. Thus, increasing the probability of linking, or networking activity, beyond an institution's original link, makes the size of (or number of institutions in) the network smaller. There is a direct correlation between the average number of connections institutions have and attachment-expansion in ParamSet 1 and ParamSet 2 (Figure 16, middle). There is a minor direct correlation between maximum degree and attachment-expansion in ParamSet 1 (Figure 16, bottom).

4.3.1.5 Attachment-stability

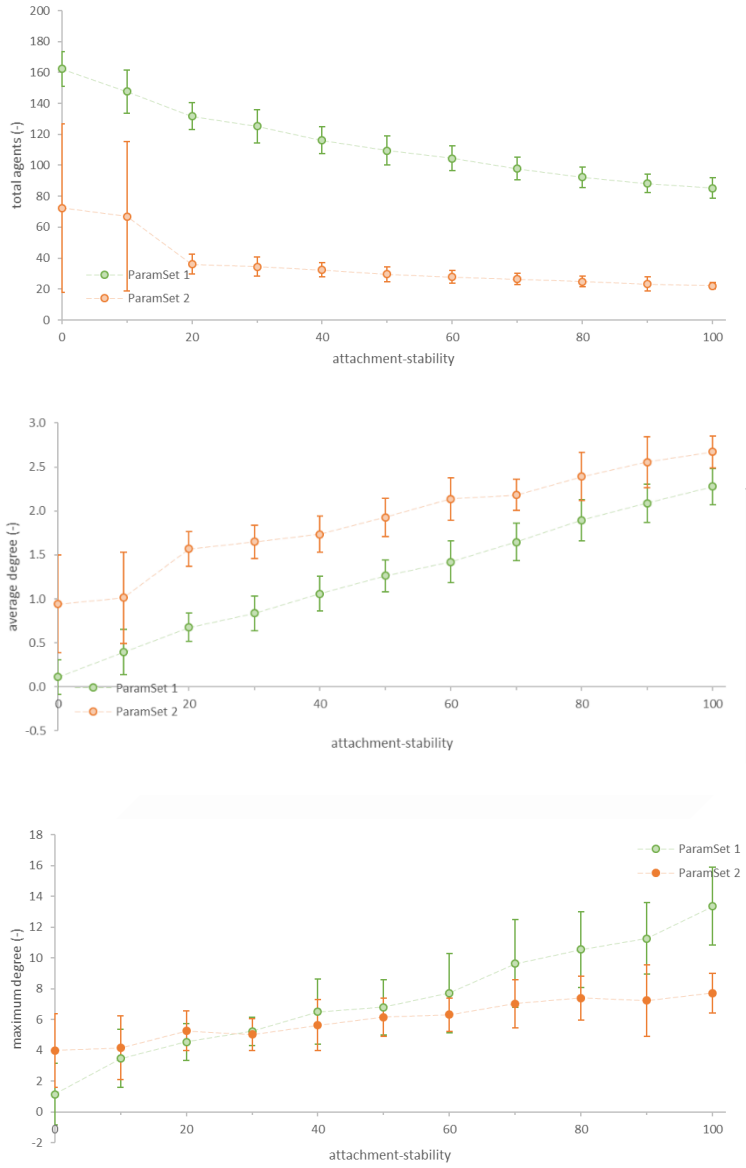


Figure 17: *Model output sensitivity to attachment-stability parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

The total number of institutions in the network decreases slightly as attachment-stability increases (Figure 17, top). Conversely, for both ParamSet 1 and ParamSet 2, there is a direct correlation between attachment-stability and the average degree or connectedness of all institutions (Figure 17, middle). Maximum degree increases in direct correlation with attachment-stability, especially in ParamSet 1 (Figure 17, bottom). This is interesting because it means that if there are more stable power relations between institutions, then the already most connected or powerful institutions benefit the most. Furthermore, and this has implications for the imperative of equity in urban waste governance systems, the number of institutions potentially benefitting decreases.

4.3.1.6 Disruptor-probability

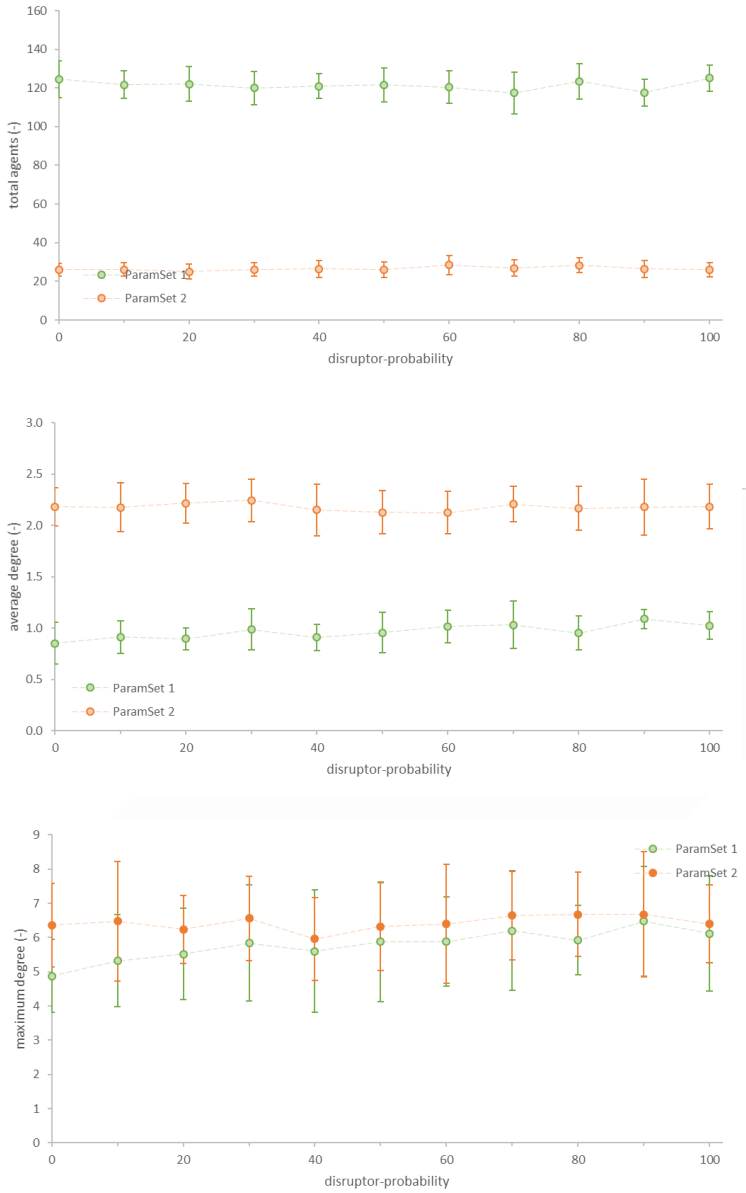


Figure 18: *Model output sensitivity to disruptor-probability parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

On its own, disruptor-probability does not appear to directly affect any network metrics. However, there is a small impact on the maximum degree, especially in ParamSet 1 (Figure 18, bottom) where other Model Settings were set at mid-low. This was especially apparent when calibrating the model to the specific SNA results for each respective city (Section 4.3.2-5). This indicates that an increased probability of a new institution entering the network, despite its corresponding waste type being adequately handled by the network, increases the connectedness of the most connected institution is. This effect is minor and more significant when random combinations of parameters are in play; that was not the case in the described here sensitivity analysis (Table 9).

4.3.1.7 Elimination-probability

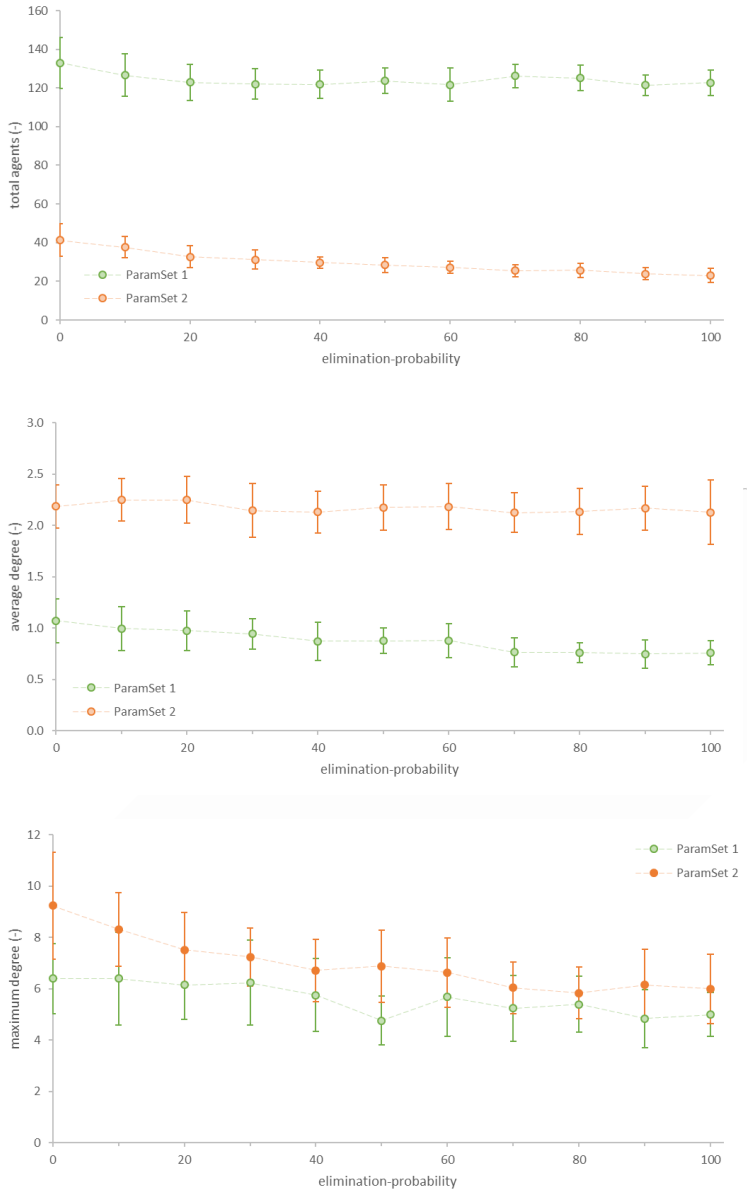


Figure 19: *Model output sensitivity to elimination-probability parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

Elimination-probability indirectly correlates with maximum degree (Figure 19, bottom). In other words, maximum degree is probable to increase as the elimination-probability decreases – or vice-versa. But as with disruptor-probability, elimination-probability's effect should be considered in heterogeneous combinations of parameters, *e.g.*, when the resilience of institutional domination comes into play – a factor incorporated by elimination-exponent. There is an indirect correlation between elimination-probability and total agents (Figure 19, top). This is more so in ParamSet 2. This is also the case for average degree, but more so in ParamSet 1 (Figure 19, middle).

4.3.1.8 Elimination-exponent

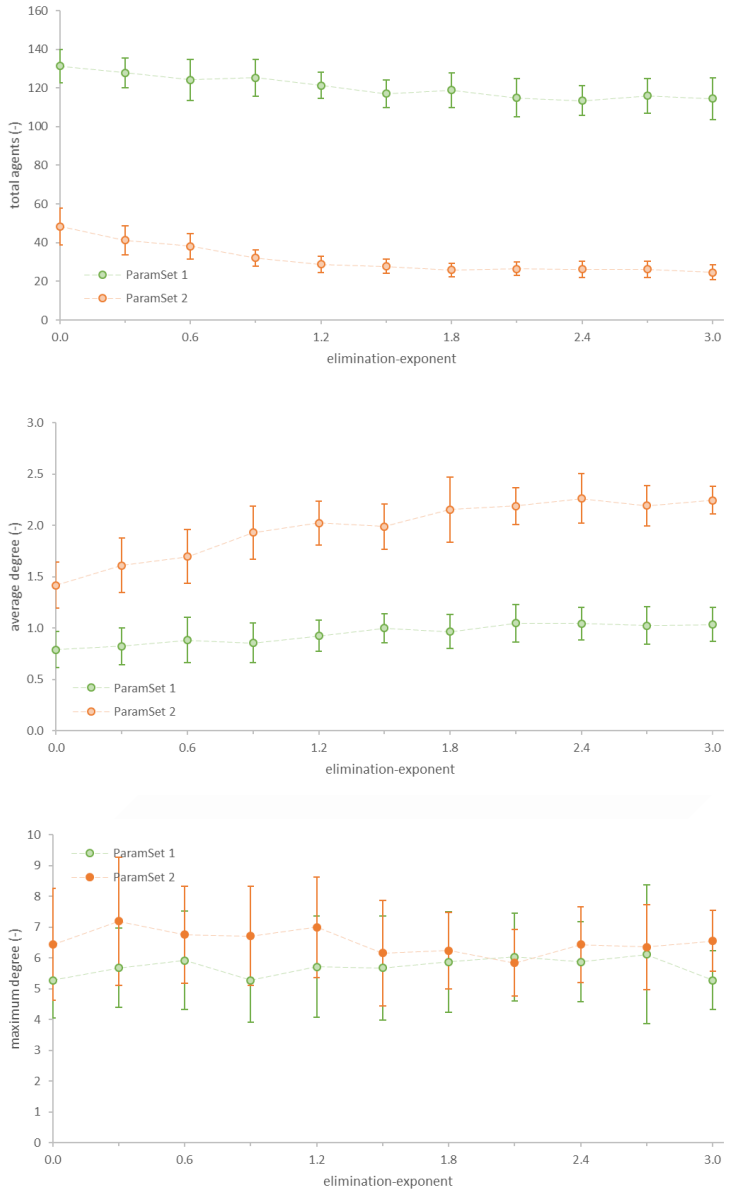


Figure 20: *Model output sensitivity to elimination-exponent parameter. Top: total agents. Middle: average degree. Bottom: maximum degree.*

The elimination-exponent has a slight, directly correlating relationship with average degree – especially in ParamSet 2 (Figure 20, middle). In other words, the connectedness of the average institution increases as resistance to institutional change increases. This may seem counterintuitive, but dominant institutions tend to serve as the epicentre or main connector of the network as a whole – thus increasing overall "inclusiveness". Elimination-exponent has a slight and indirectly correlating relationship with total agents (Figure 20, top). This is because, in this model design, each institution's waste handling capacity is construed as a variable function of its connectivity. Hence, resilient dominators mean that a smaller number of total agents are needed.

4.3.1.9 Summary

Capacity-link-influence (correlation between an institution's waste governance capacity and its connectedness), attachment-expansion (networking activity beyond an institution's original link), and attachment-stability (the probability of links breaking or remaining stable over time) had the most noticeable impact on the variability of the total number of agents (see Table 9). Attachment-expansion, attachment-stability, and elimination-exponent (an exponential function that sets incumbent resistance to elimination) had a noticeable impact on the variability of average degree. Capacity-link-influence had a significant effect on the maximum degree (the number of connections the most connected institution has), as did attachment-idolization (preferential attachment to the most connected institutions, or dominators), and attachment-stability. The attachment-expansion parameter had a less noticeable effect on the maximum degree, whilst disruptor-probability and elimination-probability had a less significant effect on all metrics. From this, I inferred that capacity-link-influence, attachment-stability, and attachment-expansion had to be configured as a matter of priority when I fitted the Scenario Settings to results obtained for each city-specific waste governance network in my SNA. This informed the simulated growth of observed networks, in terms of the real networks' total number of institutions, maximum degree, and average degree, through my model. Below, I expand on this more explanatory dimension of my modelling and the "best fit" exercise undertaken for it (Desjardins et al., 2020). I explain the city-specific Scenario Settings for each of the three cities and the respective ABM results in Sections 4.3.2 to 4.3.4 before comparing them in Section 4.3.5.

Table 9: *Differences (or ranges) between maximum and minimum y-axis values as a function of x-axis Model Settings obtained from datasets presented in Sections 4.3.1.1 through 4.3.1.8.*

	Metric Range (maximum – minimum value)					
Model Setting	**Total Agents**		**Average Degree**		**Maximum Degree**	
	ParamSet 1	**ParamSet 2**	**ParamSet 1**	**ParamSet 2**	**ParamSet 1**	**ParamSet 2**
Attachment -affinity	86	55	1.30	1.57	11	14
attachment-expansion	98	**151**	2.53	**2.96**	12	11
attachment-stability	101	**154**	2.58	**3.18**	**21**	15
disruptor-probability	57	25	1.14	1.14	9	9
elimination -probability	57	47	1.06	1.59	7	10
attachment-idolization	56	24	1.23	1.47	**21**	7

capacity-link-influence	147	**159**	1.37	1.57	10	**41**
elimination-exponent	57	46	1.09	**2**	10	9

Table 9 encapsulates the results presented in Sections 4.3.1.1 to 4.3.1.8 by showing the range of values obtained per network metric as a function of respective Model Settings. For each reported network metric per respective Model Setting, the higher of two values is underlined (when comparing ParamSet 1 and ParamSet 2). In addition, the top three values obtained per reported network metric across all Model Settings are emphasised in bold. The reason for doing this is that this exercise of comparison serves to inform the order of priority in which I adjusted individual Model Settings to reproduce the urban waste governance networks observed using SNA (that is, to generate networks with similar metrics and thus similar structure). The "best fit" exercise entailed the manual adjustment of Model Settings to consistently reproduce the same (or as proximate as possible) average degree, maximum degree, and total agents metrics of each observed city-specific network (Table 5). For each city-specific simulation series, its Scenario Settings (Sections 4.3.2 – 4.3.4 below) are configured to mirror the composition of each city-specific waste governance network in the SNA. These Scenario Settings serve as constant variables. Each best fit series comprised 1000 individual simulations within the ABM, with resulting metrics of each simulation subsequently averaged to ensure rigour. As a reminder, the purpose of this ABM application is to synthesise and simulate factors affecting the outcomes of processes of institutional change in three urban waste governance systems by extrapolating structural attributes of, and role of ideational power in, observed urban waste governance systems. The synthesis of factors affecting institutional change in urban waste governance systems are represented by the Model Settings. The extrapolated structural attributes of, and the role of ideational power in, the simulated urban waste governance networks are represented by city-specific Scenario Settings and are incorporated in the overall model design – including Model Settings. Therefore, the explanatory simulations whose results I present below serve to demonstrate (and so to effectively explain) the relative importance of interactive factors affecting the process and outcomes of institutional change in urban waste governance systems or networks.

4.3.2 Cape Town

In this section I present the ABM modelling results for Cape Town. The sections that follow (Sections 4.3.3 and 4.3.4) present the same results for Bristol and Rotterdam. I therefore do not repeat this introduction in each case. The various simulations build on a Cape Town specific

configuration of Scenario Settings which in turn build on the relevant results from the SNA. Specifically, the proportions of institution types and waste types in the ABM model were configured to mirror the composition of observed networks as presented in Section 4.1.1. SNA results informed the Scenario Setting configuration (see also section 3.5 and Table 5). In other words, the proportions of institution types and waste types in my ABM model mirrors those found in my SNA results (see Figure 21). As stated in the assumptions set out in Table 3 (Section 3.5), the "recycling" and "other" categories were merged in this ABM. The compositional element of the network remains constant, since the purpose of this explanatory modelling phase is to understand how and why observed waste governance networks resulted from complex processes of institutional change. The Model Settings I present in this section and each of the following city-specific sections below therefore represents a unique configuration of parameters or factors affecting the process and outcome of institutional change in distinct urban waste governance networks.

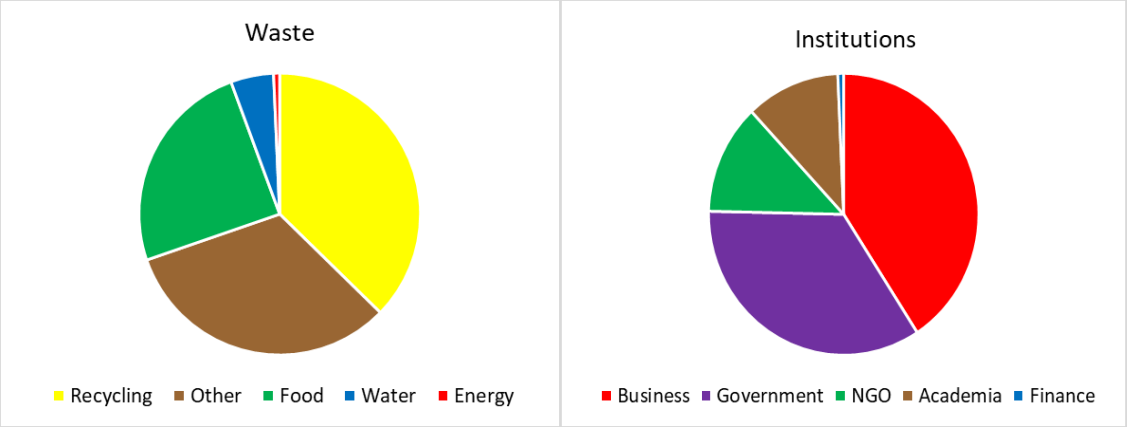


Figure 21: *SNA appraised proportion of institutions per 1) waste-type and 2) institution-type in Cape Town. These distributions across institution types were used to find a best fit between real and modelled institutional networks.*

One thousand iterations of 15 combinations of manually set Model Settings (according to relative variable weights as in Section 4.3.1) and Scenario Settings (see Figure 21) produced a "best fit" (Figure 22). The resultant metrics are average degree = 2.28; maximum degree = 35; and total agents = 143.

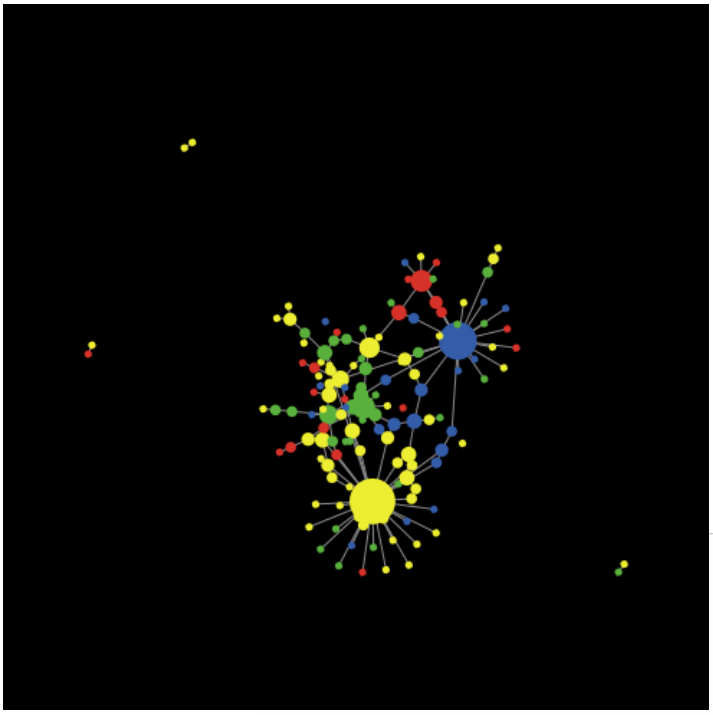


Figure 22: *NetLogo visual showing the "best-fit" simulation of Cape Town's network of waste governance institutions (water = blue, energy = red, food = green, recycling + other = yellow).*

Table 10: *Cape Town's measured network metrics that resulted in a network most closely resembling the SNA results for this city.*

Parameter	Permissible values range	Best-fit parameter value
attachment-affinity	0 – 100	55
attachment-expansion	0 – 100	65
attachment-stability	0 – 100	80
disruptor-probability	0 – 100	90
elimination-probability	0 – 100	15
attachment-idolization [e]	0 – 3 [e]	2.7[e]
capacity-link-influence [e]	0 – 3 [e]	0.2[e]
elimination-exponent [e]	0 – 3 [e]	2.2[e]

[e] exponential functions (all Model Settings without an [e] are probabilistic functions)

Table 10 illustrates those parameter values that enabled the development of a modelled network that best fit to the network structures observed in the Cape Town SNA. Going through these parameter values individually in this section, the capacity-link-influence, sets the sensitivity of an institution's waste governance capacity to its connectedness, *i.e.*, to the number of links it has with other institutions (depending on their respective types), and is an exponential function. For

the Cape Town simulation series, the capacity-link-influence value was only 0.2 out of 3, meaning a relatively low value was required to, on average, "grow" a network that fit my corresponding SNA results / metrics. Attachment-expansion, which is the probability of an institution linking or networking beyond an original link that occurs upon entering the network, is 65% for Cape Town. The attachment-stability, or probability of links remaining stable over time, is 80%. This suggests that once links are formed, they are improbable to be broken over time. The disruptor-probability, determining whether a new institution comes into the network despite its corresponding waste type being already adequately handled by the network, is 90%. This suggests new entrants are highly likely to appear and attempt to disrupt the existing network despite sufficient capacity in the existing institutional network. The elimination-probability, or likelihood that some institutions will be eliminated once a specific waste type is adequately handled by the network, is set at 15%. Within the Cape Town waste network, the attachment-affinity, or probability of preferential attachment to institutions of the same nexus type, is 55%. On the other hand, attachment-idolization, an exponential function that determines preferential attachment to the most connected institutions is 2.7. This suggests that in Cape Town, preferential networking activity is a function of connectedness, as opposed to compatibility along the lines of nexus-type attributes. The elimination-exponent, an exponential function that sets incumbent resistance to elimination, is 2.2. This suggests that in the unlikely event that existing institutions in Cape Town's network are eliminated, it will likely be relatively isolated, unconnected institutions.

4.3.3 Bristol

The SNA results informed the Scenario Setting configuration. In other words, the proportions of institution types and waste types in Bristol's ABM model mirrors those found in my SNA results for Bristol (see Figure 23).

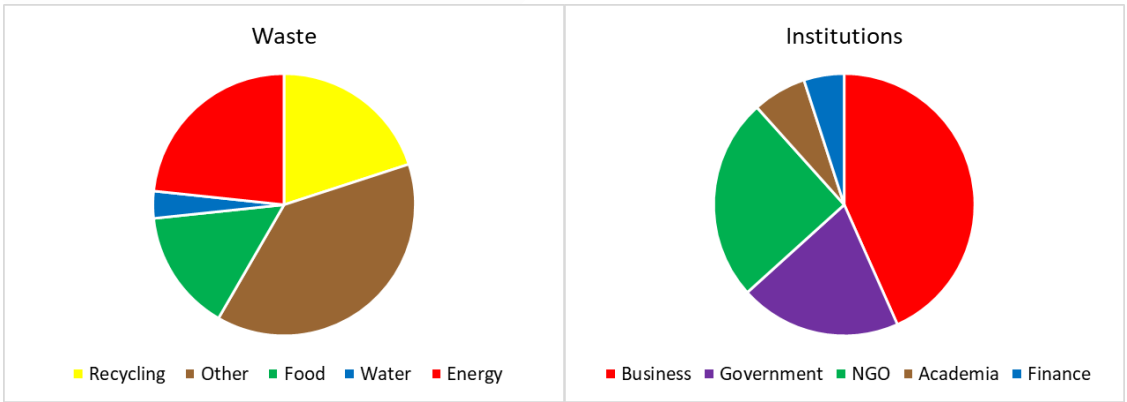


Figure 23: *SNA appraised proportion of institutions per 1) waste-type and 2) institution-type in Bristol which was used to find a best fit between appraised and modelled institutional networks.*

One thousand iterations of 15 combinations of manually set Model Settings (according to relative variable weights as per Section 4.3.1) and the Scenario Settings in Figure 23, were run to find a "best fit" between the modelled and real networks observed using SNA results for Bristol (Figure 24). Thus, the resultant metrics are average degree = 2.36; maximum degree = 14; and total agents = 58.

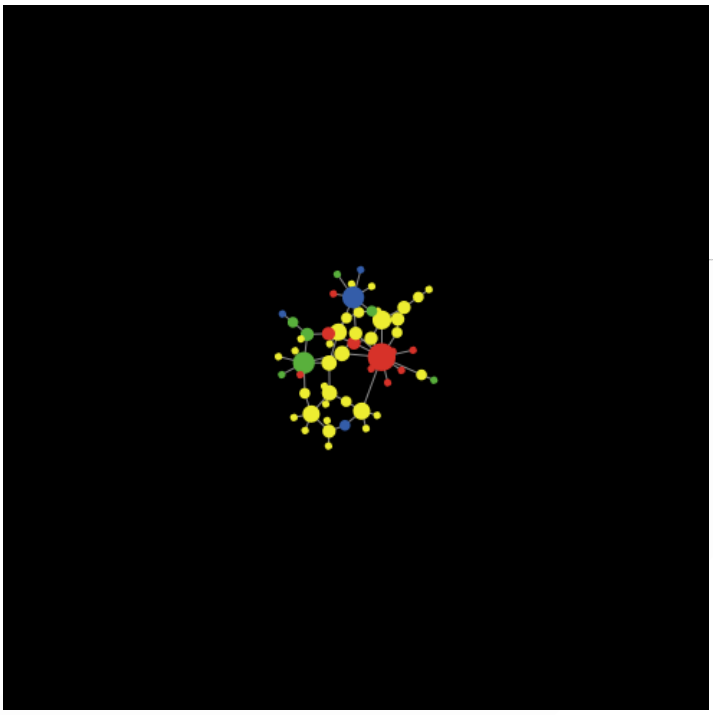


Figure 24: *NetLogo visual showing the "best-fit" simulation of Bristol's network of waste governance institutions (water = blue, energy = red, food = green, recycling + other = yellow).*

Table 11: *Bristol's measured network metrics that resulted in a network most closely resembling the SNA results for this city.*

Parameter	Permissible values range	Best-fit parameter value
attachment-affinity	0 – 100	50
attachment-expansion	0 – 100	75
attachment-stability	0 – 100	77
disruptor-probability	0 – 100	40
elimination-probability	0 – 100	30
attachment-idolization [e]	0 – 3[e]	2.6[e]
capacity-link-influence [e]	0 – 3[e]	1.1[e]
elimination-exponent [e]	0 – 3[e]	1.4[e]

[e] exponential functions (all Model Settings without an [e] are probabilistic functions)

As per Table 11, for the Bristol simulation series, capacity-link-influence, or the sensitivity of an institution's waste governance capacity to its connectedness, or the number of links it has with other institutions (depending on their respective types), is an exponential function of 1.1 out of 3 which was required to "grow" a network that fit my corresponding SNA results / metrics. This figure may appear low but is relatively high, as I indicate in Section 4.3.5. Attachment-expansion, or the probability of an institution linking or networking beyond its original link that is made upon it entering the network, is 75%. The attachment-stability, or probability of links remaining stable over time, is 77%. This suggests that once links are formed, they are relatively improbable to be broken over time. Disruptor-probability, which determines whether a new institution comes into the network despite its corresponding waste type being already adequately handled by the network, is 40%. This suggests that new entrants are less likely to appear and to effectively disrupt the existing network despite sufficient capacity of the existing institutional network. The elimination-probability, or probability that some institutions will be eliminated once a specific waste type is adequately handled by the network, is 30%. Attachment-affinity, or probability of preferential attachment to institutions of the same nexus type, is 50%. On the other hand, attachment-idolization, or the exponential function that determines preferential attachment to the most connected, or dominant, institutions, is 2.6. This suggests that preferential networking activity is a function of connectedness as opposed to nexus-type alignments. The elimination-exponent, which is an exponential function that sets dominant institutions' resistance to elimination, is 1.4. This suggests that in the unlikely event that existing institutions in Bristol's network are eliminated, it is moderately probable that it is isolated institutions that will be eliminated.

4.3.4 Rotterdam

In the same way as for the other two cities, the Rotterdam SNA results informed the Scenario Setting configuration for this ABM model. This means, that Rotterdam's proportions of institution types and waste types in its ABM model mirror those found in my SNA results for this Dutch city (see Figure 25).

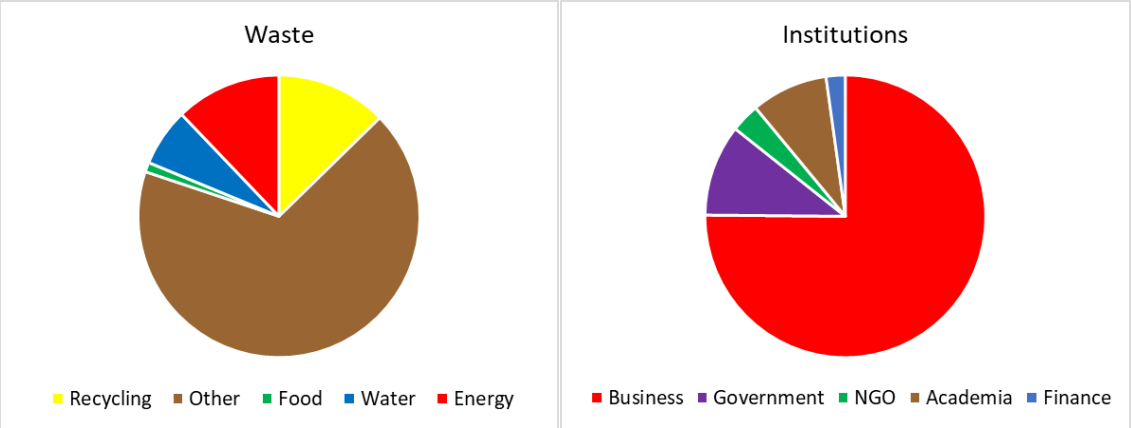


Figure 25: *SNA appraised proportion of institutions per 1) waste-type and 2) institution-type in Rotterdam which was used to find a best fit between actual and modelled institutional networks.*

Again, one thousand iterations of 15 combinations of manually set Model Settings (according to variable weights in Section 4.3.1) and Scenario Settings in Figure 25, were run to find a "best fit" between the modelled and the actual network I observed in the SNA results for this city (see Figure 26 below). The average resultant metrics are thus: average degree = 2.08; maximum degree = 49; and total agents = 189.

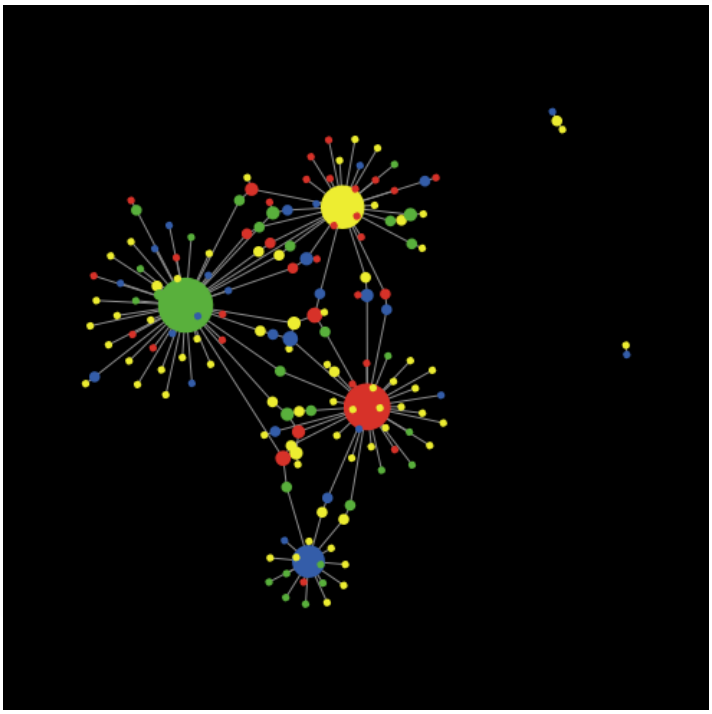


Figure 26: *NetLogo visual showing the "best-fit" simulation of Rotterdam's network of waste governance institutions (water = blue, energy = red, food = green, recycling + other = yellow).*

Table 12: *Rotterdam's measured network metrics that resulted in a network most closely resembling the SNA results for this city.*

Parameter	Permissible values range	Best-fit parameter value
attachment-affinity	0 – 100	15
attachment-expansion	0 – 100	24
attachment-stability	0 – 100	96
disruptor-probability	0 – 100	60
elimination-probability	0 – 100	5
attachment-idolization [e]	0 – 3^e	3^e
capacity-link-influence [e]	0 – 3^e	0.1^e
elimination-exponent [e]	0 – 3^e	3^e

[e] exponential functions (all Model Settings without an [e] are probabilistic functions)

As per Table 12, the capacity-link-influence, which sets the sensitivity of an institution's waste governance capacity to its connectedness or the number of links it has with other institutions (depending on their respective types), is an exponential function of only 0.1 out of 3 required to, on average, "grow" a network that fit corresponding SNA results / metrics. The attachment-expansion, or the probability of an institution linking or networking beyond the original connection it makes upon entering the network, is 24%. Attachment-stability, or the probability of links remaining stable over time, is 96%. This suggests that once links are formed, they are extremely improbable to be broken over time. The disruptor-probability, or the probability that a new institution comes into the network despite its corresponding waste type being adequately handled by the network, is 60%. This suggests that new entrants are somewhat probable to appear and attempt to disrupt the existing network despite sufficient capacity in the existing institutional network. The elimination-probability, or the probability that some institutions are eliminated once a specific waste type is adequately handled by the network, is only 5%. This suggests a high level of resilience in Rotterdam's waste governance institutions and network. The attachment-affinity, or probability of preferential attachment to institutions of the same nexus type, is only 15%. On the other hand, attachment-idolization, or the exponential function that determines preferential attachment to the most connected, or dominant, institutions, is 3 (the maximum setting). This clearly suggests that preferential attachment is a function of connectedness as opposed to nexus-type attributes. The elimination-exponent, which is an exponential function that sets incumbent resistance to elimination, is also 3, suggesting that in the exceptionally unlikely event that existing institutions in Rotterdam's network are eliminated, it is extremely probable that well-connected, or dominant institutions effectively resist institutional change and will thus not suffer elimination.

4.3.5 Comparative overview

Below, I compare and summarise my ABM results for all three case study cities in Table 13. Going into more detail, I briefly and comparatively describe the parameters (combined with the respective Scenario Settings) which generated networks with similar metrics to those appraised in my SNA of extant waste governance networks. However, a more detailed discussion and interpretation of those results is left for the subsequent discussion chapter (see, *e.g.*, Section 5.1.3).

The capacity-link-influence parameter was extremely low for both Rotterdam and Cape Town, suggesting that existing cross-institutional links have little effect on the waste governance capacity of individual institutions. For Bristol, this exponential function is significantly higher than that of the other cities, suggesting somewhat stronger correlation between cross-institutional relationships and institutional waste governance capacity.

Table 13: *"best-fit" parameters which were conducive to growing networks mimicking the average degree, maximum degree, and total agents metrics obtained in respective SNA results.*

Parameter	**Permissible values range**	**Rotterdam**	**Bristol**	**Cape Town**
attachment-affinity	0 – 100	15	50	55
attachment-expansion	0 – 100	24	75	65
attachment-stability	0 – 100	96	77	80
disruptor-probability	0 – 100	60	40	90
elimination-probability	0 – 100	5	30	15
attachment-idolization [e]	0 – 3[e]	3[e]	2.6[e]	2.7[e]
capacity-link-influence [e]	0 – 3[e]	0.1[e]	1.1[e]	0.2[e]
elimination-exponent [e]	0 – 3[e]	3[e]	1.4[e]	2.2[e]

[e] exponential functions (all Model Settings without an [e] are probabilistic functions)

The attachment-expansion parameter for the Bristol and Cape Town simulations was 75 and 65 respectively, whereas that of Rotterdam was 24, which suggests that the latter waste governance network comprises mostly of institutions that make only one initial link to the network and subsequently focus on other activities. In contrast, Bristol' and Cape Town's waste governance institutions appear to expand their network links over time.

The attachment-stability parameter was 96 for Rotterdam, 77 for Bristol, and 80 for Cape town. These relatively high numbers across city-specific waste governance networks might be a significant result. I discuss this possibility further in Section 5.1.3.

The disruptor-probability parameter was 40 for Bristol, 60 for Rotterdam, and 90 for Cape Town. This suggests that the likelihood of new entrants appearing and disrupting the existing network despite sufficient capacity of the existing institutional network is highly variable across the cities under study, with Bristol the least likely and Cape Town the most. I discuss the potential implications in Section 5.1.3.

The elimination-probability, or likelihood that some institutions will be eliminated once a specific waste type is adequately handled by the network, was 5 in Rotterdam, 30 for Bristol, and 15 for Cape Town. These are all relatively low figures, with Rotterdam being the most extreme case of resilient institutional dominance (appearing to resist change).

Attachment-affinity was 15 for Rotterdam, 50 for Bristol, and 55 for Cape Town. This suggests that networking activity in Rotterdam is most indiscriminate in terms of nexus-type categories.

The attachment-idolization parameter was 3 for Rotterdam, 2.6 for Bristol, and 2.7 for Cape Town. As these are exponential function, the results are relatively high across cities. This suggests that preferential networking activity is a function of connectedness rather than nexus-type attributes, but especially so in Rotterdam. I discuss this more in relation to established theory in Section 5.1.3.

The elimination-exponent was 3 for Rotterdam, 1.4 for Bristol, and 2.2 for Cape Town. This suggests that dominant institutions in Rotterdam are extremely resilient to disruption or change, whilst those in Cape Town are moderately to highly resilient to disruption, and those in Bristol are only slightly resilient to institutional change.

The capacity-link-influence was 0.1 for Rotterdam, 1.1 for Bristol, and 0.2 for Cape Town. These seemingly low, but significantly variable, figures (considering that the capacity-link-influence is an exponential function) are discussed in Section 5.1.3.

Whilst these specific results are discussed in a focused manner in Section 5.1.3, the comparative results also factor into my discussion of specific hypotheses – for example, in Section 5.2.3.

5 Discussion

The purpose of this chapter is to explain, discuss, and interpret results obtained in this study in detail. This includes the literature reviewed in Chapter 2, the methods outlined in Chapter 3, and corresponding data and results presented and described in Chapter 4. I evaluate and elaborate on both research findings and the methods used to make such findings with reference to the research design presented in Chapter 1. As a reminder, going back to Chapter 1, the questions that I answer in the following discussion are:

1. What is the composition and structure of urban waste governance systems wherein the circular economy and food-energy-water nexus concepts have become institutionalised?

2. How does ideational power relate to emancipatory institutional change in contemporary urban waste governance; and what does this mean for social-environmental challenges?

3. What factors influence the process of institutional change in urban waste governance systems; and what compositional or structural outcomes emerge over time as a result?

I answer these questions respectively in Sections 5.1.1 to 5.1.3. In Section 5.2, I revisit my hypotheses and reflect on my contribution to the literature reviewed in Chapter 2. In Section 5.3, I caveat this by reflecting on the limitations in my research design. In Chapter 6, I conclude with a summary and recommendations for practice, policy, and future research.

5.1 Research questions

5.1.1 Structure and composition of urban waste governance systems

The structure and composition of urban waste governance systems is a theoretically and practically relevant issue. Stemming from my reading of critical institutionalism theory, which forms the first pillar of my theoretical framework in this thesis, the interplay of structure and agency has been a key theme throughout this thesis. To pay attention to this interplay can illuminate the institutional fabric of urban waste governance systems, and thus foreground inequities that may be neglected or reproduced through these systems. A systemic approach is essential to evaluate how the institutionalisation of CE and FEW nexus concepts structures or influences waste governance in social and environmental terms. At the same time, however, it is necessary to dissect urban waste governance systems; to critically analyse their constituent institutions and potential asymmetries of power between them. To do this, below I discuss the results derived from research question one. I start by briefly outlining how different parts of my research methodology and literature review contributed to answering different components of the first research question. Then, I elaborate on procedures used to formulate a multifaceted answer

to the question in a step by step way – thus reflecting more extensively on what informed each part of it. Next, I present a detailed discussion of specific results which informed my answer to the first research question – with an emphasis on SNA results as well as key qualitative results.

There are three core components of my first research question: the i) structure-, ii) composition-, and iii) constitutive fabric of waste governance systems in cities wherein the CE or FEW nexus concepts have become institutionalised. In terms of structure, answering the first research question has been informed by environmental governance theory in Section 2.2.1 and results obtained from my application of the SNA method in Section 3.3. The **structure of urban waste governance systems** is network-like and variably asymmetrical. In terms of composition, (critical) institutionalism theory in Section 2.2.2 and results obtained from my application of the SNA method in Section 3.3, as well as my application of the qualitative analysis method in Section 3.4, largely informed the answer. The **composition of institutionalised CE and FEW nexus concepts** is dominated by business and government institutions – but this answer must be caveated by important contextual variability. As for **whether the institutionalisation of CE and FEW nexus concepts** in business and government dominated networks indeed **constitutes urban waste governance systems**, the answer is yes – but, again, there are important contextual variations which I draw from respective city-specific findings. In the remainder of this section (Section 5.1.1), I attempt to explain exactly how my interpretation of the relevant results and findings led me to this multifaceted answer.

Reflections on selecting and applying SNA as my first methodological step

In order to explain how my interpretation of the literature, methodological design, and results produced the position that says the institutionalisation of CE and FEW nexus concepts take a network-like, asymmetrical form, I first reflect on selecting and applying SNA as my first methodological step. How I chose and applied SNA was motivated, first, by my reading of CE and FEW nexus literature.

First, my critical reading of CE literature, to begin with, indicates that there is an obscure but distinct aspect to this idea which revolves around its paradigmatic or discursive significance for policy and practice (Blomsma & Brennan, 2017). Also, it reveales that there is a markedly widespread adoption of this concept among governments of wealthy nations (Ghisellini et al., 2016; Ranta et al., 2018). Moreover, I find instructive systematic reviews which suggest that the CE and FEW nexus concepts are showing up in a vibrant academic debate – chiefly literature that is focused on physicality (Parsa et al., 2021). Furthermore, Parsa et al. (2021) confirm a key gap in the debate: overemphasis on sustainable flows of resources and waste minimisation to the exclusion of social emphases. Specifically, in alignment with my critique of the CE idea for

overemphasising material optimisation, Parsa et al. (2021) also find that the CE concept shows mainly technical-material and environmental-economic potential. This resonates with empirical accounts of how the CE concept's neglect of (unequal) social context manifests in all three cities included in my study. In my assessment, this manifestation is problematic if the CE, at least insofar as it seems to be enunciated with scientific or academic authority, is popularised and institutionalised with an air of social neutrality. This problem does not exclusively arise in cases where the CE idea is enunciated in scientific circles – it arises even more strongly in instances where the CE idea is expressed in political and commercial circles; with what I call pragmatic authority. In the latter regard, Cowell et al. (2020) provide an instructive analysis of how politics and trade relations around the CE are interdependently tied to a highly technical-economic stake in established waste governance systems. My point here is that such a technical-economic interest does not suggest a homogeneous institutional landscape. In heterogeneous social and institutional contexts, which characterise large trading blocs like the EU Single Market (if we continue to use the case study provided by Cowell et al. (2020)), I suspect that only a highly assimilative discourse imbued with scientific and pragmatic authority could precipitate in such a widespread institutionalisation of the CE concept – despite its air of social neutrality. This suspicion leads me to the critical notion of power in ideas (Carstensen & Schmidt, 2016). The real-world social implications or outcomes of such assimilation makes the absence of substantive social considerations in its discourse problematic. Taken together, these readings led me to undertake a critical analysis of a seemingly discursive process of CE institutionalisation – with an emphasis on who is involved and how they might relate to one another.

Second, my critical reading of FEW nexus literature indicates that this idea's discursive strength relates to its origin in authoritative economic forums of resource management (Waughray, 2011; Hoff, 2011). In both conceptual and methodological terms, this origin is evident in critiques of the challenges associated with its technical-material-economic foundations (Mohtar, 2016; Daher et al., 2018; Urbinatti et al., 2020). That technical-material-economic foundation of the concept as I understand it is partly the reason why my SNA design took a critical approach and why I selected SNA as the first step in my full methodological design – in addition to earlier introduced reasons (see Section 3.3). Additional reasons include the inadvertent advancement of capitalist logic and conceptual confluence between the FEW nexus and governance. The latter reason is a problem because of the FEW nexus concept's potential importance for contentious and far-reaching policymaking processes (Bazilian et al., 2011; Allouche et al., 2019). Therefore, it is worth restating that these latter reasons for my selection of the SNA method as well as my specific application thereof interacts with my conceptual and analytical frameworks.

The literature is suggestive of institutional diversity in those instances where the FEW nexus concept is being institutionalised (Leck et al., 2015). But at the same time, there is a lack of critical consideration of how (if at all) such heterogeneity might precipitate in governance that fosters meaningful institutional change (Stinger et al., 2014; Weitz et al., 2017). I align my SNA with the *critical* slant which several scholars advocate for such considerations (*e.g.*, Allouche et al., 2019), by, for example, taking a critical stance on the tacit notion of CE's social innocuousness (Parsa et al., 2021) and the notion that narrative congruence between institutions in different sectors (*e.g.*, FEW sectors) increases environmental governance capacity (Koch et al., 2021). Therefore, as I set out in Section 3.3, FEW nexus categories (with their antithetical sectoral silos) are built into my SNA application. This is done with the aim to open my analysis to the institutional diversity allegedly typifying FEW nexus (and CE) institutionalisation by introducing a generic institution type categorisation. Further, building on the founding scholars of both governance theory (Rhodes, 1997) and social network theory (Wellman et al., 1996), I took an online-based approach to data collection which aligned with my critical reading of the CE and FEW nexus concepts as vehicles of ideational power (see Chapter 2) in a societal context of capitalism and a highly interconnected age of information technology.

Answering my first research question depends on a comparative case approach, which scholars at the forefront of SNA applications call for (Bodin et al., 2019; Koch et al., 2021). These calls come in explicit relation to environmental governance theory, which is one of the two pillars in my theoretical framework. Underpinning this pillar, which I focus on in this paragraph, is (my reading of) literature inviting SNA applications that focus on systemic phenomena (Borgatti et al., 2009). I find precisely such an invitation within environmental governance literature whereby we are entreated not to get stuck in questions of process, nor to stretch the intelligibility and role of individual intent or agency in environmental governance (Beunen & Patterson, 2019). At the same time, crucially, my decision to undertake a *critical* reading of governance theory in the first instance sensitises me to longstanding calls for caution with regards to the egalitarian and democratic façade of governance *networks* (Rhodes, 1997; Kooiman, 1999). In terms of my SNA, this means, for example, that a high number of institutions featuring in a given waste governance network does not necessarily imply that that system is inclusive or open to institutional change. And this, combined with the calls for scholars not to reduce their analyses to an exercise in naval-gazing, motivated me to simplify my SNA design and to focus on *emergent properties of whole networks* – and compare said properties (Borgatti et al., 2009). That is, a comparison of the structure and composition of several networks.

Before engaging in a detailed discussion of my specific SNA results, note that my critical engagement with environmental governance theory contributed to my decision to read critical institutionalism theory, enabling me to incorporate considerations of power and inequality. This is important because ever-active processes of institutional change – and the (temporary) outcomes these manifest – cannot be understood and accounted for without attending to inequalities of opportunity (Van Assche, Beunen & Duineveld, 2014; Carstensen & Schmidt, 2016; Larsson, 2018; Beunen & Patterson, 2019). I deal with potential asymmetries of power in more detail in the following section (Section 5.1.2) and engage directly with the methodological mixture and data triangulation these readings inspired in Section 5.1.3. For the purposes of my first research question, the theoretical insights above informed my selection of properties I have appraised, measured, and reported on in comparative fashion in my application of the SNA method. In what follows below, I move from a procedural to an output-focused discussion of results in Chapter 4.

Detailed discussion of the structure and composition of studied waste governance networks

A visual analysis of results presented in Section 4.1 indicates a high level of asymmetry in the appraised institutional networks of all three cities included in my study. See Table 14 below for an easy-to-reach visual comparison. From a sectoral perspective, seemingly powerful generalists (institutions which perform a variety of functions or manage various wastes), such as local government councils, big recycling businesses, and facilitating third sector institutions (NGOs), appear to be well positioned near network centres. On the outskirts of the appraised institutional networks, FEW nexus specialists seem more prominent than such generalists and are often clustered – a trend that is clear in the Cape Town and Rotterdam waste governance networks. From an institutional perspective, businesses dominate the Rotterdam network, government entities are particularly prevalent in Cape Town, and third sector prominence only features strongly in Bristol. Business-government relations underpin every institutional network. Institutions focused on energy and food feature prominently in Bristol. Those focused on energy and water feature prominently in Rotterdam. If we ignore institutions disconnected from the local waste governance network, institutions focused on water are underrepresented in Cape Town.

I set out to better understand the composition and structure of the institutionalised circular economy and food-energy-water nexus concepts. Composition here refers to the nature of the constituent institutions, or the identity of institutions that together constitute the whole network. Structure refers to the patterns of relations between institutions, and in this I highlight the *overall* structure of the network. In terms of composition, identifying and critically analysing some attributes of these structures in cities results in the revealing of three distinct institutional networks that directly relate to my theoretical framework, as I set out above. This theoretical relation stems

from the purposeful systematic search which I used to identify the sample. The three networks were appraised to answer my first research question. As described in Section 3.3, this appraisal is based on online impressions, representing a sample captured with a systematic search and web scraping exercise using the keywords or phrases "circular economy (city)" or "food-energy-water nexus (city)". Given this approach, discursive institutional alignment with CE and/or FEW nexus ideas can thus be inferred from these results.

Unambiguous and apposite alignment with either or both of these concepts is clearly apparent for institutions both in Rotterdam and Bristol, whilst mostly tangential or ambiguous alignment with either was moderately apparent for Cape Town. I infer such alignment from both the number of discrete and directly relevant web domains which resulted from each systematic search, as well as from additional manual web domain analyses. Further, I analysed case specific SNA results categorically along the lines of "institution-types" and "FEW nexus types" because I anticipated that these categorisations, or at least my manual attempt to apply these categorisations, would yield insights into the composition of their institutional networks. In both European cities, businesses seemingly dominate the institutional networks. Another similarity between Bristol and Rotterdam in terms of network composition is that there appears to be a vibrant energy-waste governance niche in both settings. All three city-specific samples comprise well positioned "generalist" institutions, or entities categorised as "other" because they do not squarely fit into any FEW nexus niche or into the "recycling" category. These generalists seem to hold the main networks' peripheral clusters together.

Major identified differences between the appraised institutional networks are mainly of a structural nature. However, there is also an important element of composition to these differences. Most notably, business connections are integral to both Bristol's and Rotterdam's overall network composition and structure whilst in Cape Town, commercial institutions seem peripheral, entirely disconnected from brokering institutions. This is reflected by a clear dominance of government institutions in Cape Town's waste governance network. Furthermore, this dominance would be amplified if clusters that are disconnected from the main network are excluded from measured network metrics (however, I did not exclude them in the SNA for Cape Town since this would render several seemingly relevant institutions invisible).

Visually apparent divergences between the respective cases in Section 4.1, which I further analyse by comparing network metrics in Table 5, indicate that Bristol's institutional network is an outlier in terms of both structure and size. More specifically, the Bristol network has a high average degree, a low maximum degree, as well as a low number of total agents or institutions identified. A visual analysis of outputs for Bristol vis-à-vis those of Cape Town and Rotterdam is indicative

of a more tightly knit institutional network in Bristol, where a relatively homogeneous mixture of institution-types and (FEW) nexus-types co-exist. In terms of composition, comparing Rotterdam and Cape Town reveals stark constrast insofar as business prevalence is concerned. Conversely, the respective structures and sizes of these two cities' waste governance networks are somewhat similar, though Cape Town is a much larger city with significantly more residents (see Table 7).

Three network metrics are reported quantitatively: average degree, maximum degree, and total agents (Table 5). Further, the unique i) degree (Figures 8, 10 and 12), and ii) eigenvector centrality (Figures 7, 9 and 11) of each individual institution included in the appraised networks is visually reported as node size functions. "Degree" reflects the number of connections each institution has, and "eigenvector centrality" reflects the "influence" each institution has – also considering its neighbours' connections. These measurements are useful when observing the relative difference between those most "influential" or connected institutions, and those that are least "influential" or connected within a single network. But it is also useful for visual analysis of the relative differences in average connectedness and influence between respective networks. When visually comparing Figures 7, 9, and 11 it becomes apparent that, at least in terms of eigenvector centrality, Rotterdam hosts the starkest difference between most and least "influential" institutions (Figure 11). Conversely, Bristol's results reveal the smallest difference between the most and least well-connected institutions among any of the three networks being studied (Figure 9).

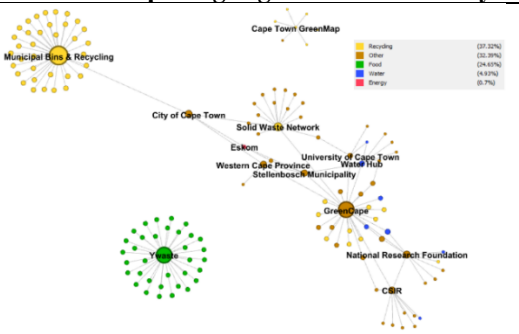
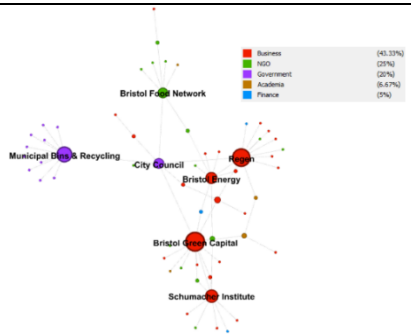
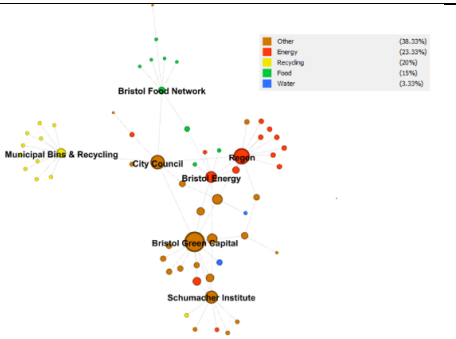
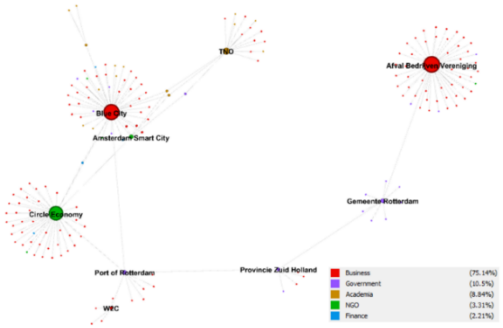
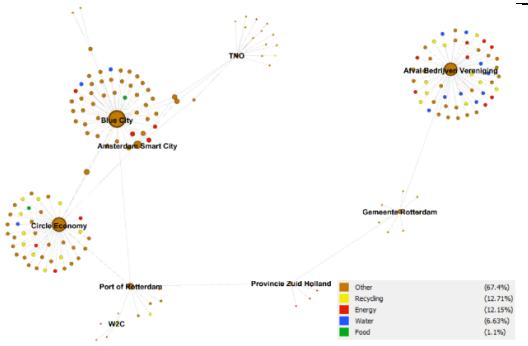
Between the respective city-specific networks, there are noteworthy similarities and differences which are reflected not only by these metrics but also by the compositions depicted in Table 14. Notably, the City of Cape Town's "Municipal Bins & Recycling" constitutes most of its FEW nexus types ("recycling") according to the categorisation applied in this study: approximately 30% of the entire network. This suggests that the metropolitan government has total control of a large aspect of the appraised waste governance network. Bristol City Council's Municipal Bins & Recycling (to reiterate, this is an artificial label applied across cities for comparative purposes) also constitutes a notable cluster in its network, albeit a less prominent one comprising approximately 20% of Bristol's appraised waste governance network. The equivalent cluster in Rotterdam is anchored in Gemeente Rotterdam, and it comprises a relatively negligible proportion (approximately 10%) of the overall governance network.

In what follows, all networks being described are those identified and presented in Section 4.1. Table 5 shows that the governance network in Bristol (Graph Density: 0.039) is more than twice as "dense" as those in both Cape Town (0.015) and Rotterdam (0.012). This means that the average institution aligning itself with either FEW nexus or CE concepts in Bristol is twice as likely to be proximate to institutions wielding ideational power, or dominating the local network,

when compared to average institutions in either Cape Town or Rotterdam. Network density in Cape Town is approximately 60% lower than that of Bristol, whilst Rotterdam's network density is approximately 70% lower than that of Bristol. This means that the average institution aligning itself with either FEW nexus or CE ideas in Rotterdam is less likely to have access to likeminded institutions in that city, if compared to Bristol. This network density may reflect highly mobile individuals with multiple institutional identities in Bristol's smaller, more diverse network, as compared to the relatively high degree of privatisation or businesses in Rotterdam and the relatively strong role of government in Cape Town. However, Cape Town is more closely aligned with Rotterdam in terms of network metrics. This can be observed in Table 14 below. Table 14 summarises the structural and compositional differences and similarities between respective cities. For example, Rotterdam' and Cape Town's networks are structurally similar, but compositionally different in that business is most prevalent in the former and government is prominent and strategically positioned between large clusters in the latter.

Again, had the institutions included in Cape Town's appraised network been limited to those that are connected to the main network, it would have been smaller and featured little to no business institutions. This is despite Cape Town's large population (Table 7). This is different from Rotterdam's network, which consists largely of (75%) business institutions that appear to be integral to the "giant component" or main network (Figure 12). In Cape Town, a central spine of government institutions holds the somewhat peripheral clusters of academic and third sector institutions together – and virtually no finance institutions appear to align themselves with FEW nexus or CE concepts and their principles (Figure 8). This suggests that those institutions which advertise their alignment with, or implement, these principles are likely to be dependent on local government buy-in in terms of access to financial and material resources in Cape Town. In Rotterdam, such implementing institutions seem to be more independent of government assistance, but rather dependent on the popularity of CE and FEW nexus principles among private consumers with sufficient buying power to sustain them financially over the long term (Interviewee D, 2021). In Bristol, the relatively large percentage of third sector institutions and financial institutions which seem to align themselves with these principles suggests that there is some money flowing from sources other than local government and private consumers. However, the strategic positioning of major businesses in close connection with local government institutions in Bristol's network suggests that there is a harmonious combination of private and public flows of various resources anchored in discursive alignment with the CE and (more especially) FEW nexus concepts.

Table 14: *Visual comparison of the networks across research sites. Notice their differences and similarities in terms of structure and composition.*

City	Node sizes depicting Degree	Node sizes depicting Eigenvector Centrality
Cape Town		
Bristol		
Rotterdam		

In the remainder of this section, I answer the final part of my first research question – which emphasises the constitutive fabric of the urban waste governance systems I analysed.

The constitutive fabric of the urban waste governance systems

After having explained my interpretation of the research outputs and suggesting that the main observed outcome of CE and FEW nexus institutionalisation is the formation of asymmetric networks dominated by businesses and governments – albeit with such domination being highly complex and appearing to be contextually variable – I now reflect on whether these networks constitute urban waste governance systems; *i.e.*, highly interconnected, complex, dynamic, and diverse webs of institutions dealing with urban waste in a material, regulatory, or semantic / discursive way. So far, I have interspersed this discussion with interchangeable reference to institutional networks and waste governance networks. This is intentional and purposeful as the answer to my question is yes – but, again, there are contextual variations I identify and interpret based on city-specific findings. At the risk of pre-empting some content of the following sections (Section 5.1.2 to Section 5.3), I should caveat this answer in two ways. Firstly, this "yes – but" answer is conditional on my interpretation of results obtained from my qualitative analysis as well as from my SNA results. And, as I set out in Section 3.4, results from my qualitative analysis ultimately interacted with my choice of theoretical framing – especially insofar as my selection of environmental governance theory was concerned, but also regarding critical institutionalism theory. Again, my reading of the latter theory, in conjunction with my reading of selected critical sociological writings, reinforced my foundational notion of ideational power as well as my critical and relational understanding of discourse, which my SNA was ultimately designed to investigate (Boltanski, 2011; Carstensen & Schmidt, 2016; Duygan et al., 2021). Secondly, there is a risk that my answer is a self-fulfilling prophecy. This is because, following logically from the first caveat I just explained, my answer to the question as to whether the analysed institutional networks constitute urban waste governance systems is subject to a level of interpretation which I cannot rightly skim over or cursorily hint at. Furthermore, the way in which I, as the researcher and author of this thesis, formulated my SNA application is anchored in the same reading (my reading of environmental governance theory) informing my interpretation of its results in terms of whether these networks constitute urban waste governance. I discuss limitations in Section 5.3 below.

I will now further expand my answer with reference to my overall findings. My argument that the appraised institutional networks do indeed form a key part of the constitutive fabric of urban waste governance systems partly draws from the inclusion of familiar institutions operating in the "broad church" of waste governance – as interpreted based on the relevant theory in Section 2.2.1. It also draws on confirmation of my research results and this interpretation by representatives of

such institutions. Dominant network institutions, and crucially their relations with each other (which my SNA identified on the basis of relative connectedness with other institutions) also align with CE and/or FEW nexus ideas expressed on their respective online profiles. Such institutions are plainly recognised by interviewees as being the dominators. However, akin to the founding conceptualisation of governance I adopted in this research, these institutional networks do not comprise a singular hub of institutional control as has been the norm in the traditional nucleus of government (Rhodes, 1997; Kooiman, 1999).

To illustrate, Bristol's appraised network indeed comprises a notable element of municipal bins and recycling, and a rather prominent Bristol City Council, but the structure of this network suggests that these are on a relatively equal relational footing vis-à-vis other institutions. Despite this, interviewees representing such other institutions rather point to the *relationship* between local government and key businesses as the locus of concentrated financial power and key decision-making processes. Hence, whilst some regulatory intervention is needed, this is often beyond the competence of a nevertheless highly involved local government.

In Rotterdam's appraised institutional network, there is a weak government component in an expansive and structurally sprawled network – and, indeed, government representatives are unusually transparent, describing their role as limited to facilitation. An interviewee representing an academic institution clearly stated its leadership's inclination to avoid financial dependence on any government.

Perhaps the most compelling, in Cape Town where an unusually high proportion of government institutions comprises an also sprawling and expansive network, – indeed, some non-government clusters are entirely disconnected from the main network – and there seems to be a vicarious trend insofar as a highly influential local-provincial government exerts "soft power" through a range of sub-ordinate institutions whose level of independence is impossible to establish. Yet, despite a peculiar form of apparent structural and compositional dominance, regional government fails to outmatch the material performance of independent and un-institutionalised individual urban waste pickers (impoverished individuals who do crucial recycling work in South African cities, but have nonetheless been subjected to exploitation, condemnation, and discrimination).

Lastly, my findings are consistent with current trends in environmental governance theory insofar as the snapshots of waste governance networks which my SNA produced are just that: momentary or synchronic impressions of systems which are apparently in a constant state of flux (Allouche et al., 2019; Cowell et al., 2020; Partelow et al., 2020). The close comparability of the waste governance networks in my SNA and familiar patterns of economic and political dominance in each of the three case study cities is consistent with the discursive turn in contemporary

environmental governance theory (Duygan et al., 2021; Koch et al., 2021). Based on my critical reading of Beunen & Patterson (2019), I qualify my argument that the observed waste governance networks are in constant flux with the proviso that the depth, direction, and meaning of such change is uncertain. There may be certain institutions in relatively dominant positions (insofar as ideational power is concerned) which work to influence such processes of structural and compositional change *per se* (the processes). Through such influence, these institutions may maintain the institutional asymmetry of power and the appearances of transformation in terms of the full/whole networks of waste governance institutions, thus making them appear progressive.

Overall, my SNA findings indicate that the degree and specific nature of institutional diversity varies contextually between cities. There is a well-connected and balanced range of institutions which align themselves with (especially) FEW nexus ideas in Bristol, a particularly expansive mix of institutions (albeit their level of integration in the network varies widely) which align with (especially) CE ideas in Rotterdam, and a relative paucity of unified institutional diversity aligned with either of these ideas in Cape Town. The political landscape in each city also differs, thus making the impulse to ingrain its waste governance system with egalitarian principles varied. For example, a Labour dominated political landscape in Bristol resonates with its relatively high average degree network metric, and with the rather explicit affirmation of third sector institutions' importance and a perceived unreliability of businesses that are central to the governance of waste. The Democratic Alliance (governing Cape Town and the Western Cape) is a pro free-market political institution; resonating with the inaccessibility of GreenCape's WISP platform – which may be the most relevant database of institutions which concertedly embrace the CE and FEW nexus concepts in and around Cape Town. Affirmations of structural and compositional dominance of business-driven, or entrepreneurial, waste governance in Rotterdam emanates from an involved and supportive national government ruled primarily by the People's Party for Freedom and Democracy, the second in charge conservative-liberal political institution in a ruling coalition with Livable Rotterdam in local government at the time of writing.

In closing, two key aspects of the asymmetrical waste governance systems – which I interpret as equivalent to the institutional networks appraised in my SNA for reasons set out above – remain undiscussed. First, a more nuanced consideration of *why* these networks are *what* I have argued they are (including their contextual specificities in terms of structure and composition). Second, a discussion about dynamicity – or the omnipresence of institutional change – which might provide some meaningful insights as to *how* these networks become what they are, and perhaps remain what they are, over time. I consider these two aspects in turn in Sections 5.1.2 and 5.1.3.

5.1.2 Ideational power in urban waste governance networks

For ease of reference, the question I answer in this section is about how ideational power (see Section 2.2.2) relates to emancipatory institutional change in waste governance networks – and whether this relation is conducive to the alleviation of social-environmental challenges. "Emancipatory", as I also argued in Section 2.2.2, means the effective resistance of domination. With the advantage of hindsight (i.e., having already conducted the analysis of my case studies), I will here return to the theory I elucidated in Section 2.2.2. However, before doing so, I want to highlight that this answer also leans on my critical reading of environmental governance, circular economy, and food-energy-water nexus literature. Likewise, whilst I draw mainly from my qualitative results, other results also factor in. To answer my second research question, I draw on two data sources. First, I draw secondary data from my reading of critical institutionalism theory in Section 2.2.2. Second, I draw primary data from my qualitative analysis method, which I explained in Section 3.4 and whose results I presented in Section 4.2. As usual, my answer draws from the outputs of my mixed methods comprising my overall methodological design. In the first part of this section (Section 5.1.2), I address the first aspect of my answer – which is mainly informed by the literature, and in the latter part I focus on the second aspect using my results.

Without diminishing the fascinating and multifaceted nature of the question and the answer to it, my synthesised answer to the first part of the second research question is that **ideational power** is closely **related to emancipatory institutional change** in three key respects. First, ideational power seems objectively neutral but is contextually biased, correlating with ideational power's theoretical versus its practical import for *emancipatory* institutional change. Second, the nexus of financial and political control may play a key role in the qualitative determination of contextual interplays between the power in ideas (Section 2.2.2) and practical emancipatory institutional change. And third, there seems to be contextual variance in terms of the degree to which critical thinking and ideational dissent have become "mainstream" features of waste governance processes – with a lack of correlating variance in apparent levels of potential for emancipatory institutional change. Overall, the relative availability of relevant data or information had significant implications for the scope of evaluative learning and emancipatory institutional change driven by critique in the waste governance networks in question. As to **whether this relation is conducive to the alleviation of social-environmental challenges**, my findings indicate that it is not. My research across all three case studies illustrates, as I discuss below, that emancipatory change in regulatory and material norms remains elusive despite variable levels and types of ideational dissent (Section 5.2.2).

Lessons from the literature on ideational power and emancipatory institutional change

The first part of my answer relates to critical sociological perspectives on the diminishing impact which critique has on capitalism as a problematic "institutionalised social order" or "form of life" (Fraser & Jaeggi, 2018; Boltanski & Fraser, 2021). In my early readings of institutionalism literature (not only the critical variety I ultimately chose to focus on; all those I outlined in Section 2.2.2), I was struck by a convoluted labyrinth of self-referential scholarship wherein the virtue of *critical* institutionalism was questioned vigorously – with an apparent dissonance between its academic dominance and practical irrelevance being one of the main targets (Wilmott, 2015). In what I consider to be an instructive implosion of an otherwise vitally useful school of thought, turning its analytical and conceptual force onto itself instead of directing it toward actual issues, strong defences of critical institutionalism theory's practical emancipatory potential have been dovetailed by ascriptions of its intellectual dominance to "*academic careerism*" (Lok, 2018, p. 347). This might seem to be something new or tangential in relation to the subject matter at hand in this section, but it is not. As I will elucidate in the second and especially the third parts of my answer to the research question at hand in this section (Section 5.1.2), taking note of the underlying cause of "academic careerism" was instructive for the manner in which I critically analysed qualitative data I presented in Section 4.2. Ideational power – as I conceptualised it in my research design: manifesting as instantiations of capitalism's logic of commodification in environmental (waste) governance networks in cities – is a broad concept which can be understood in a variety of ways depending on one's perspective. I therefore opted to narrow it down and selected Carstensen & Schmidt's (2016) power *in* ideas – which emphasises the version of ideational power which restricts imaginaries of alterity, thus catalysing hegemony. And, yet Carstensen & Schmidt (2016: p. 333) conclude by arguing that the implication of their proposed definitions of ideational power might "*enhance the ability of discursive institutionalists to track the agents, whether collective or individual, who have the ideational capacities to affect the context in which interests are defended and to assign them responsibility accordingly*". The issue which Lok (2018) – who belongs to another tribe of institutionalism altogether, if we are trying keep track of the convoluted theoretical bifurcations – admits is thus evident in some of the very same literature which defends institutionalism against serious critiques of its practical irrelevance.

The point I want to make with this assessment is that the systematic exercise of ideational power could be an industry in itself. My interpretation of the results suggest that this is the case in urban waste governance. Many, if not most, of the institutional representatives I engaged in interviews had nothing to do with physical operations involving literally handling waste in the cities which they were based in. Moreover, Interviewee E (2020) was one of the few who represented an

institution which performs substantive physical waste handling operations in Bristol – and yet, "*collaboration, policy, and lobbying*" had recently become a key part of what the institution in question does. Whilst this may in part reflect the seniority of those representatives, it is also important to note that the sample selection for invitations to interviews was based on an SNA which foregrounded institutions with ideational power – based on those institutions' alignment with the CE or FEW nexus concepts. This relates to foundational works of Rhodes (1997) and Kooiman (1999), as well as the point made by Carstensen & Schmidt (2016): responsibility is an elusive target. In other words, as the contemporary concept of governance provides, responsibility and accountability has been dis-located and therefore the systemic trajectory of urban waste governance networks *seems* more contestable than ever before. This is doubly so if we consider the current context of abounding information and communication technologies whereby ideas diffuse so rapidly that it becomes challenging to trace their origins, trajectory or ultimate effects. There is a distinction to be drawn between the ordinary everyday operations of waste management in cities and the more value-laden processes and outcomes of institutional change in urban waste *governance* systems or networks. My argument here situates such processes and outcomes within the broader context of what direction our urban societies may move in.

This brings me to how this apparent trend relates to emancipatory institutional change – or the potential for it. I argue that ideational power, and indeed the specific notion of power in CE and FEW nexus ideas which I employed in my research design, is objectively neutral in the sense that its effect (which I hypothesised as restricting imaginaries of alterity in urban waste governance to commodification) can *generally* be thought of as indeterminate. In other words, it is difficult to attribute a universal pattern of outcomes to any given degree of power in these specific ideas (and even more so in terms of ideational power more generally); as one might wish to in theorising its relation to emancipatory institutional change. I advance this point despite (and perhaps precisely thanks to) my undertaking of comparing three respective case studies. In contrast, when thinking about ideational power, and specifically power in the CE and FEW nexus ideas, in the context of urban waste governance networks and their potential for emancipatory institutional change *in specific places* – I argue that there are knowable effects, even if only at a single moment in time. I can illustrate this point with examples from each of the three cities I used as case studies by associating the relative degree of apparent CE and/or FEW nexus concept institutionalisation with a relative degree of *apparent* potential for emancipatory institutional change in waste governance.

Ideational power seems objectively neutral but is contextually biased

In Bristol, I find a high level of online alignment with FEW nexus ideas despite the overall size of the appraised waste governance network being relatively small. The institutional diversity

which distinguishes the Bristol sample might be indicative of a relatively high potential for emancipatory institutional change. But I argue that it rather indicates a high level of active critique. Take the Bristol Food Policy Council. With representatives from a range of institutions including the local food industry, Bristol City Council, Bristol Food Network, universities, and grassroots bodies – the Bristol Food Policy Council's purpose is to serve as a mechanism through which actions for a sustainable and inclusive food system can be co-governed; constituting a *de facto* "*informal extension of the local state*" (Reed & Keech, 2019, p. 7). Nevertheless, Interviewee I (2021) said that, in Bristol, companies producing waste of all sorts (food was the example used) only channel that to recycling centres or other entities that can productively use it when such waste channelling does not incur additional expenses of money and effort. Further, the problem that waste minimisation activities tend to be confined to (weak) legal obligations was commented on critically (Interviewee I, 2021). Yet, despite such critique and a strong alignment with the FEW nexus (and some CE) concept(s) (and the power which such alignment might afford), fundamental emancipatory institutional change is elusive. This may suggest that the power I have assumed to be embodied in the adoption and discursive use of the FEW nexus and CE concepts is overstated. Or, as Nunes (2017) argues about what food justice might mean in a global capitalist system interacting with unique places, the adoption and discursive use of FEW nexus and CE concepts may be a nascent form of "*pragmatist ethics*" – or localised attempts (or Bristolian attempts in this case) to make ends meet in an institutional setting that limits practicable transformative change. So, whilst unable to effectively resist what I call the diluted dominance of institutions in Bristol's waste governance system, disruptors enter the fray and reform it slightly.

In Cape Town, where CE and FEW nexus ideas are hard to trace in its relatively fragmented network of waste governance institutions, Interviewee B (2019) stated unambiguously that the fundamental structure of local government operations is not compatible with the institutional change required to bring about a circular economy. By extension, Interviewee B (2019) said the political will to bring about radical change was not forthcoming in the years she/he had spent trying to promote emancipatory waste governance in Cape Town from within local government. Further, secondary sources indicate that a material part of the waste governance system in Cape Town (if we take governance to include a physical dimension) has been omitted from processes influencing the existing institutional arrangement despite that part (waste pickers) doing most of the recycling without any formal resourcing or infrastructure to support their operations (Perez, 2017). That is, institutional inertia and interdependencies of commercial and governmental control are not conducive to emancipatory institutional change in Cape Town's waste governance. However, calls for such emancipatory institutional change are clearer here than in either Bristol or Rotterdam despite (or perhaps thanks to) a relatively low institutionalisation of CE and FEW

nexus concepts. This low level of institutionalisation coincides with a more blatant exclusion of relevant "stakeholders" (waste pickers are the key example here) and the obvious negative impact the status quo still has on disempowered change agents when compared to Bristol or Rotterdam.

In Rotterdam, where there is a patently consistent and commonplace alignment with CE ideas in businesses and government, interviewees indicated that local government is indeed supportive of circular economy initiatives, in large part due to its constructive relationship with a supportive national government despite ideological differences. The financial independence of academic and *quasi* third sector waste governance institutions is pivotal, businesses are dominant, and only a few social enterprises around waste governance are operating in Rotterdam (Interviewee D, 2021). Incumbents (which already disrupted mainstream local government controlled waste governance networks) are increasingly opening themselves up to disruption and influence through collaboration as regulation disincentivises waste; but, at the same time, disruptors claiming to collaborate are allegedly entering a new, uncooperative network of exclusive power (Interviewee F, 2019). Again, the potential for emancipatory institutional change does not appear to correlate with widespread coverage of a regime of ideational power anchored in the CE concept, and so on.

Financial and political control, power in ideas, and emancipatory institutional change

However, and therefore I argue that the institutionalisation of CE and FEW nexus concepts is contextually biased insofar as emancipatory institutional change is concerned, in Rotterdam and Cape Town I find discursive utilisation of either concept *in pursuit of* emancipatory institutional change. To make this argument I revisit the meaning of emancipation in the relevant theoretical context. Contrasting this with the objective neutrality of the institutionalisation of these two (CE and FEW nexus) concepts, akin to institutionalism, the *criticalness* of discourses employing these concepts emerges insofar as I interpret a varying degree of "*emancipatory intent*" in it (Lok, 2018, 337). Such intent seems to be present in statements contradicting the domination which unquestioned institutions necessarily imply – that is what it means to be critical (Boltanski, 2011). With some variation between the cities in question, I observe such contradictions interspersed throughout statements made by interviewees, as in those I paraphrased in the previous paragraphs.

The specific content of imagined alternatives is beyond the scope of my research. However, the force in favour of emancipatory institutional change is widespread whilst the specific outcomes which the realisation of such change might produce seem contextual. For example, Interviewee B's (2019) statement that the entire structure of local government should change, and that private sector finance should be leveraged begs for regulatory and semantic limitations to be dismantled in order to realise the goal of material sustainability in practical terms. Nonetheless, reference to unequal distributions, or asymmetries, of power manifesting in a bloated local government

suggests an emancipatory interpretation of what the ultimate CE, or the FEW nexus, should be. In Bristol, also by way of example, there are virtually no explicit references to a CE or FEW nexus as some kind of institutionalised outcome in any shape or form. But, perhaps as a result of the FEW nexus concept's establishment in a complex institutional landscape (relatively interconnected and diverse, with third sector institutions featuring more strongly in my SNA for Bristol compared to others), there are clear and direct suggestions that certain policies should be reinforced whilst others should be loosened, thus arguing that the regulatory dimension should change for material sustainability with special reference to food waste. Again, albeit in less blatant form, there is clear and critical reference to a concentration of financial flows in the city's waste governance network as well as local economic inequalities, besides national fiscal asymmetries.

In Rotterdam, as in Cape Town, government officials state openly that solutions to date may have been over-focused on the technical and incremental "circularisation" of existing economies – as opposed to the elimination of old ones and the creation of a new, distinct "circular economy". "… *do we focus on incremental changes that are doable, and can be used in current projects, or rather systemic changes? … Do we focus on reusing existing structures or realising new ones in a fully circular way?*" (Interviewee H, 2020). Further, there is directly critical comment about the lack of formal policy making processes which might bring about constructive chaos through the destabilisation of existing waste governance networks in the city. The similarity in terms of critical reference to existing structures in Rotterdam and Cape Town is interesting in that these two cities also displayed structural similarities in terms of my SNA results.

The nexus of financial and political control thus influences the qualitative determination of contextual interplays between the power in ideas and practical emancipatory institutional change.

Contextual variations in ideational dissent and its role for emancipatory institutional change

This calls for more discussion about the differences and similarities of how the power in CE and FEW nexus ideas is mobilised divergently in respective cities relative to associated levels of criticality, which I argue is evident from each city's small sample of institutional representatives. I find contextual variance in terms of the manner in and degree to which critical thinking, or ideational dissent, has become a "mainstream" activity in waste governance processes – without correlating divergence in seemingly low potential for emancipatory institutional change across all three cities. To illustrate, I highlight some critical statements and draw out qualitative patterns from institutional representatives typifying the ideational dissent in each city's waste governance.

In Cape Town, interviewees are particularly critical about government's role in stifling change in waste governance. Interviewee A (2021) said that environmental and international development

policies trying to regulate waste governance are not necessarily making a difference, and yet there is a consistent pattern of government trying to maintain a tight grip on financial flows from waste. However, this contrasts sharply with findings from secondary literature, describing institutions which featured in my SNA results for Cape Town, but which were unavailable for interviews in 2021. For example, the Solid Waste Network represents independent individual waste pickers – a group which is acutely under-represented in formal waste governance and has seen the sharp end of exploitative processes of institutionalisation in other major South African cities (Samson, 2022). In Cape Town, however, the Solid Waste Network maintains a relationship with local government and delimits its mission to providing more formal and organised access to recycling markets for waste pickers who would otherwise attempt to partake in such markets informally and, hence, without any bargaining power. Another instructive example is that of GreenCape in general, and its Western Cape Industrial Symbiosis (WISP) programme in particular. Perhaps the most cross-cutting institution (itself, one might argue, a third sector extension of the Western Cape government), connecting many others, GreenCape's operational focus is regulatory and semantic insofar as it emphasises the provision of policy advice and networking opportunities (GreenCape, 2021). More specifically, its WISP programme serves as a commercial liaison which effectively matches businesses whose outflows of waste outputs could serve as inflows of raw material inputs for productive industrial processes. At a glance, WISP thus seems to embody an extra-governmental institutionalisation of both CE and FEW nexus concepts revolving around the commodification of waste in and around Cape Town. In my view, GreenCape is a good example of a formal institutional embodiment of critical thinking since forums hosted by GreenCape do include a variety of voices who are variably inclined to ideational dissent. But this happens at arm's length from government rather than facilitating intensely critical statements from current and former government officials. It may thus be an indication of *incremental* institutional change.

To further illustrate the latter point, one influential government official at the national level stated that "*politics is a real inhibitor of progressive fiscal mechanisms*" that are required to resource the emancipatory institutional change in South African waste governance needed to bring about a CE. This statement came at the South Africa-European Union Strategic Partnership Dialogue Facility hosted by the National Research Foundation, whose premises are located next to the CSIR – another government institution identified in my SNA and accountable to the same department as the National Research Foundation. In this statement, the official implicitly advanced collaborative principles insofar as the critique I highlighted above was extended by emphasising that inter-departmental collaboration and coordination is crucial if the overall South African waste governance system is to change meaningfully (in that case, using the CE as the systemic outcome of such deep change). Echoing the same sentiment with regards to local government, Interviewee

B (2019) indicated that neither the level of political will nor the level of fiscal priority assigned to waste governance is conducive to emancipatory institutional change – especially since the temporality of the democratic cycle dominates all processes of structural change more generally.

In Bristol, interviewee statements and my SNA results confirm explicit secondary literature references to the United Kingdom's prominent third sector (Burns, 2019). The moderately high level of business institutions comprising a relatively interconnected and dense waste governance network does not appear to be an overt target of critique. Interviewee C (2021) indicated that businesses play a major role in the overall waste governance network, but Bristol City Council tries to coordinate this and capitalise on it with its own "*extremely important*" Bristol Waste Company. Similarly, instead of strong critique being directed at government's role in general, there are popular critical statements regarding national government's perceived refusal to disrupt established institutional arrangements (Interviewees C & I, 2021). This resonates with a strong pro-Bristolian trend in the more self-affirming online profiles of institutions which feature prominently in my SNA results, such as the Bristol Waste Company itself and Bristol Energy (the latter has since been subsumed by British Gas). Perhaps due to what seems like an affirmative understanding of the emancipatory role that businesses play in Bristol's waste governance network, the significant profitability of some prominent institutions such as GENeco and Wessex Water is not a target of internal critique. However, Interviewee I (2021) strongly criticised the apparently high level of immunity some businesses enjoy from waste regulations if they fall into defined categories of financial hardship – which contrasts with high levels of poverty in Bristol (Michelac, 2020; Interviewee J, 2021). A distinct property of all this critique in Bristol's waste governance network is the effective agency of dominant businesses such as GENeco, from which a great deal of resistance should be expected if emancipatory institutional change is actively pursued to their detriment (Interviewee I, 2021). Such domination represents institutionalisations of CE and FEW nexus ideas since, still using GENeco as an example, the dominant institution would be defending sunk costs in its own food waste recycling systems. Epitomising the notion of contemporary governance I drew from Rhodes (1997) in this research, Bristol City Council's "coordinating" role is perhaps more pivotal than my SNA results suggest. If we "follow the money", as Interviewee I (2021) suggested we should, there is a clear linear flow of money from ratepayers to Bristol City Council, to the Bristol Waste Company, and (within the boundaries of my research scope) lastly to GENeco – not to mention the valuable flows of recyclable waste which this relation facilitates. Businesses, especially those operating at the nexus of food and energy waste, are using their distinct level of agency to call for more mandatory regulation of food waste – contrary to national government's voluntarism – which would secure a stronger and more reliable flow of waste. Such institutional change would not be emancipatory in my view.

The last peculiarity of Bristol's institutionalisation of CE and FEW nexus ideas relative to the manner in and degree to which critique seems to have become a mainstream activity in its waste governance network is the prominence of third sector organisations. This prominence again highlights the structural and compositional distinctness of Bristol's waste governance network, at least insofar as my comparative case study of three cities is concerned. Importantly, unlike The Netherlands and South Africa, UK water supplies are privately owned. However, perhaps exactly because of its distinct structural and compositional qualities, a prominent third sector does not appear to have major implications for the institutional dominance of business and government; albeit that local government's domination is discursively juxtaposed to that of the national level and appears to be embodied in an especially relational or indirect way, if compared to Cape Town. This perhaps correlates with the relatively high importance ascribed to individual capacity and mobility in a waste governance network characterised by a high level of institutional diversity.

In Rotterdam, an overarching theme emerging from descriptions of the waste governance network is its entrepreneurial character. Within a sprawled structure, like Cape Town, this characteristic underpins online profiles of various institutions including those that I have categorised as third sector in my SNA results. Unlike Cape Town, however, the institutionalisation of (especially) CE and FEW nexus concepts is patent, and the composition of Rotterdam's institutional network mainly involves an unambiguous domination of the business component. Rather than being focused on influencing and placating governmental institutions at any level, most of my qualitative findings indicate a discursive focus on business and (only secondarily) its important role in governance. For example, Circle Economy – being a rather obvious embodiment of CE's institutionalisation in Rotterdam – mainly concerns itself with integrated approaches to empower businesses, cities, and governments more generally to embrace and implement CE principles. Blue City, another key institution identified in my SNA, expressly makes overcoming legal and fiscal barriers part of its mission – alongside the goal of fostering "unbreakable" institutional networks of start-ups and dominant businesses capitalising on new CE and FEW nexus value chains in Rotterdam. A noteworthy anomaly in Rotterdam's waste governance network is the relative prominence of academic institutions and the proximity of such institutions and the critical thinking they provide to prominent businesses and entrepreneurial, *quasi*-third sector institutions like Circle Economy. There is a relatively large number of academic institutions associated with Blue City itself, and I find a proximate cluster of academic institutions anchored in The Netherlands Organisations for Applied Scientific Research ("TNO" in Figure 12). Commenting on the relationship with Blue City from an academic institution's perspective, Interviewee F (2019) alluded to a dissonance between Blue City's online self-representation and its behaviour. Data contradicted institutionally produced "truth" at the time of data collection (Boltanski, 2011).

More specifically, if we take Interviewee F's (2019) critique seriously, the relative proximity of Blue City to academic institutions in the overall waste governance network is significant, given its sprawled and linear structure (recall that the appraised networks are discursive). On the one hand, interviewee F (2019) stated that the inauthenticity of Blue City's self-portrayal was nonetheless functional since it effectively cast an ideational net wherein research funds can be and are caught. On the other hand, its *un*-collaborative reluctance to share data and work with institutions which could not impart resources directly contradicts its online profile and undermines governance goals of evaluative learning. Interviewee G (2020) was particularly critical of the overall lack of focus on decommissioning or winding down dominant institutions – although such critique is not directed at any specific institution or group of institutions. Contrarily, Interviewee H (2021) self-critiqued from a senior position within a department of national government that it may be a mistake to focus on introducing incremental-technical institutional changes rather than focusing on achieving fundamental change. Interviewee H (2020) said that a lack of data sharing may be due to a pursuit and maintenance of competitive advantage. Thus, the potential for emancipatory institutional change is constrained through economic competition and the desire to maintain the advantage of being a frontrunner. Lastly, local government was critiqued by Interviewee D (2019) for its self-inflicted exposure to long-term contracts with businesses dependent on flows of certain waste types for certain forms of waste commodification. However, at the national level of government, Interviewee H (2020) unambiguously and uniquely indicated that the imperative of experimentation and failure for (critical) evaluative learning is understood to foster emancipatory institutional change in Rotterdam's waste governance system.

I find that the degree to which critical thinking has become a common phenomenon in the waste governance networks is *relatively* high in Bristol, moderate in Cape Town, and low in Rotterdam. Such an assessment warrants qualification. Toward such qualification, I summarise the manner in which critical thinking has become a mainstream activity in the waste governance networks in question by comparing them with reference to the "traditional nucleus": government. Contrary to the relative level of apparent CE and FEW nexus concept institutionalisation in each respective city, I contend that the level of effective critique is highest in Bristol and lowest in Rotterdam. Local government's dominant role in Bristol seems relatively diluted and/or buffered, where a tightly knit network of highly critical third sector institutions and businesses dominate. In Cape Town, all levels of government seem to dominate with a combination of political and fiscal motivations – thus evoking fierce and overt critique from its own representatives and others. Local government seems all but absent in Rotterdam, where businesses and entrepreneurial third sector institutions dominated – with only academia and national government voicing marginal critique. There is a caveat to this: I did not interview local government representatives in Rotterdam.

However, as I discuss further below, ABM results for Rotterdam indicate a low probability of institutional change with regards to structure and composition in its waste governance network. In Section 5.2.2, I juxtapose varying levels of critiques I infer from each respective network with their abilities to alleviate social-environmental crises through emancipatory institutional change.

5.1.3 Institutional change in urban waste governance networks

In this section, I answer the final (two-pronged) research question: what factors influence the outcomes of institutional change in urban waste governance networks, and what compositional or structural outcomes emerge over time as a result? To do this, I draw mainly on my agent based modelling method described in Section 3.5 which, as I explained there, is an extrapolation of results I obtained from my SNA and qualitative analysis as well as from my critical overall reading of the literature in Chapter 2. Without pre-empting my critical consideration of the overall methodological design as part of the assumptions and limitations applicable to my study (Section 5.3), I repeat the rationale for using ABM in my mixed method methodology to thoroughly contextualise the discussion of results that follows here. I do so in the first part of this section (Section 5.1.3) below, before addressing the first part of my final research question with reference, firstly, to the exploratory sensitivity analysis of my model's dynamics as presented in Section 4.3.1 and, secondly, with reference to my explanatory simulation of appraised institutional networks as presented in Section 4.3.2. Thus, I will discuss the apparent import of formative factors influencing the structural and compositional outcomes of institutional change in waste governance networks as per the relevant part of my methodology (Section 3.5). I integrate this discussion with interspersed consideration of my findings discussed in the previous sections (Sections 5.1.1 and 5.1.2), thus enabling qualitative inferences about the wide subject matter. This holistic consideration of my overall findings lays the groundwork for a critical reflection on my contribution to selected literature in Section 5.2, as well as my presentation of recommendations and implications stemming from the thesis – which I summarise and conclude with in Chapter 6.

Factors influencing the outcomes of institutional change in urban waste governance networks

Throughout this thesis, I have referred to the diversity, dynamicity, and complexity of both the practical context of contemporary cities as well as the theoretical framing of my subject matter. Urban waste governance networks, as an example of environmental governance systems, are in a state of constant flux; this is what I have called the omnipresence of change in my research design. With respect to the research problems I introduced and departed from in Section 1.3, there are global social-environmental challenges which should inform any critical evaluation of local environmental governance trends. Koch et al. (2021) argue that such trends are currently failing to deliver local transformation in society – which is required for the effective alleviation of such

big challenges. I concur with this assessment, and thus I took a step further by attempting to critically analyse real manifestations of such trends whilst rejecting positivism by focusing rather on stochastic, indeterminate processes of institutional change in urban waste governance networks at given places and times. Taken together, my acceptance of the omnipresence of change and my rejection of positivism had direct implications for my methodological design: it means that SNA and qualitative analysis are insufficient for a thorough critical analysis of processes and outcomes of institutional change in environmental governance systems, using the case of waste in cities. That is, I had to extrapolate the institutional networks I appraised using SNA to see how they grow and change over time (Barabasi & Albert, 1999), while the qualitative results I obtained and analysed using an abductive-retroductive approach could not be used on their own to ascertain unambiguous chains of cause and effect (Tikly, 2015; Stutchbury, 2022). Hence, I designed a mixed method methodology combining SNA, qualitative analysis, and ABM. In the same vein, I opted for a comparative case study to further contextualise and triangulate combined results.

Generic and exploratory agent based modelling sensitivity analysis results

Starting with generic, non-contextual terms based on my agent based modelling sensitivity analysis findings, the answer to the third research question is that (in a descending order of magnitude) attachment-stability, attachment-expansion, capacity-link-influence, attachment-idolization, and elimination-exponent **influenced structural and compositional outcomes** of simulated institutional change in urban waste governance networks (Table 9). Specifically, in structural terms, increased attachment-stability decreases the size or total number of institutions in a network. Increased attachment-stability increases the average degree and increases the maximum degree. Increased attachment-expansion decreases the size or total number of institutions and increases the average degree (it has a negligible influence on the maximum degree). On the other hand, increased capacity-link-influence decreases the size or total number of institutions (only disruptor-probability has a slight direct correlation with total agents) and decreases the maximum degree of a network (it has a negligible influence on average degree). Increased attachment-idolization increases the maximum degree of a network (it has a negligible influence on both total institutions and average degree). And, lastly, increased elimination-exponent increases the average degree (it has negligible influence on the size of a network, or its total number of institutions, and the maximum degree). In the remainder of this section (Section 5.1.3), I elaborate on this answer and extend it to include the compositional dimension with reference to my overall findings. In the ABM sensitivity analysis, the composition of simulated waste governance networks remained constant. Hence, extensive discussion of results obtained

from alternative analytical means (SNA and qualitative analysis, in this case) is necessary to understand what factors correlate with observed compositional outcomes of institutional change.

Table 9 (p. 123) shows the results of my sensitivity analysis of operative parameters in my ABM design by indicating relative ranges of specific network metrics obtained from a generic simulation series. I discuss Table 9 halfway into this section, and then discuss city-specific scenarios. The sensitivity analysis was conducted as a necessary generic exercise unrelated to city-specific findings from my SNA. Instead, it is a demonstration of my model design (Section 3.5.1) in action, presented with the same network metrics I used to process and compare data in my SNA (Section 4.1). This demonstration essentially enabled me to test the systemic influence of each parameter (see Table 4), which are factors extrapolated from my SNA and qualitative results as well as from my reading of the literature. Therefore, the ABM model allowed me to better understand context-specific variations of urban waste governance networks and the structural drivers of their potential change over time. Hence, I first discuss each of the eight parameter's respective influence on relevant network metrics in the same order as results were presented in Section 4.3.1.

Attachment-affinity, or the probability of preferential linking with others of the same nexus-type, does not have a strong influence on the total number of agents in the network or the average degree – being the average connectedness of agents or institutions in the network. This is so for both ParamSet 1 (where all other parameters were configured at mid-low; see Table 8) as well as ParamSet 2 (where all other parameters were configured at mid-high; see Table 8). However, there is a weak influence: increased attachment-affinity marginally decreases both the total agents and average degree of the network. In contrast, attachment-affinity has a notable but stochastic influence on the maximum degree network metric. Decreased attachment-affinity correlates with increased maximum degree – with the strongest trend of indirect correlation seen in ParamSet 2. If attachment-affinity is contrary to FEW nexus principles – which foster cross-sectoral synergies between institutions, or non-attachment-affinity – its minor indirect correlation with structurally desirable network metrics (total agents, average degree) negates FEW nexus principles. On the other hand, its indirect correlation with structurally undesirable network metrics (maximum degree) affirms FEW nexus principles. To anchor this finding in my conceptual framework of context in the interaction between research and government policy, and in my theoretical framework of environmental governance and critical institutionalism, I explicitly qualify this value judgement of what is structurally desirable and undesirable on the basis of my reading of critical sociology: emancipatory institutional change defies domination (Rhodes, 1997; Searle, 1997; Vira, 1997; Kooiman, 1999; Boltanski, 2011; Boltanski & Fraser, 2021). Low average

degree, few total agents, and high maximum degree indicate disparity (domination) with regards to ideational power in contemporary urban waste governance systems (Barabasi & Albert, 1999).

The next parameter is attachment-idolization, which is a key feature of Barabasi & Albert's (1999) finding that preferential attachment between nodes (or institutions) is integral to how networks grow or evolve over time. I find that this parameter neither noticeably affects average degree nor the total agents network metric. This result is consistent for both ParamSet 1 and ParamSet 2. As expected, attachment-idolization has a strong effect on the maximum degree network metric. There is a direct correlation between attachment-idolization and the maximum degree network metric, especially in ParamSet 1 but also in ParamSet 2. This correlation is characterised by a high level of stochasticity (unpredictability) at upper increments of the setting. Theoretically, the generic relevance of disparity in the distribution of links has been attributed to a relatively high level of "*local decisions made by the individual* [nodes]*, based on information that is biased towards the more visible (richer)*" nodes – irrespective of the nature and origin of such disparity in relational gravity (Barabasi & Albert, 1999, p. 8). But I argue that the nature and origin of such disparity in numbers of network connections is important (Rhodes, 1997; Vira, 1997). In this study, I relate it to ideational power in either or both of the CE and FEW nexus concepts. As I will discuss in the latter half of this section (Section 5.1.3), the relative attachment-idolization required to simulate networks with metrics closely matching that of studied waste governance networks is therefore a function which interacts with the degree to and manner in which CE and FEW nexus concepts seem to be institutionalised.

The capacity-link-influence is the correlation between an institution's waste governance capacity and its connectedness to other actors within the network. This parameter has a major effect on both the maximum degree and total agents network metrics, as well as a minor effect on the average degree network metric. First, total agents decrease as capacity-link-influence increases. This line of correlation is linear for ParamSet 1 and somewhat curved for ParamSet 2, which perhaps reflects the fact that this parameter is an exponential function (attachment-affinity and attachment-idolization parameters discussed above are probabilistic functions). As a reminder, ParamSet 1 is where all parameters other than the one in question are set to mid-low or at 33% of the maximum setting, whereas ParamSet 2 is where all parameters other than the one in question are set to mid-high or at 66% of the maximum setting. In terms of average degree and maximum degree, the capacity-link-influence does not seem to have an effect for ParamSet 1. For ParamSet 2, the maximum degree metric is sensitive to capacity-link-influence with a high level of stochasticity at lower increments of this parameter. Again, there is an indirect correlation whereby initial increases to capacity-link-influence cause significant decreases in the maximum degree

metric, a correlation which tapers off as the setting reaches higher figures. Also, for ParamSet 2, the average degree metric is somewhat sensitive to capacity-link-influence as initial increases to this parameter causes minor increases to average degree and thereafter further increases cause minor decreases in average degree, visible as a slightly arced curve. Relating this to my selected theory, capacity-link-influence embodies the synergistic implication of relational networks of contemporary environmental governance where power is characteristically diffuse. More specifically, for example, it can be seen as an operationalisation of the notion of narrative congruence argued by Koch et al. (2021) – whereby individual-to-collective governance capacity is imparted by virtue or as a function of ideational alignment caused by a process of persuasion. But, as I have argued up to this point, I take a different approach which is critical and applies a systems thinking analytical frame rather than highlighting individual nodes (Borgatti et al., 2009). My findings on capacity-link-influence reinforce such an approach: even though neither its effect on maximum degree nor on average degree can be considered conclusive if we consider the variance between ParamSet 1 and ParamSet 2, its effect on total agents is strong and clear. It suggests that the greater the effective relevance of relationships in constituting systemic capacity, the lesser the probability that many institutions will be part of the governance network. Still, the opposite qualification applies if we evaluate the effect capacity-link-influence has on maximum degree in ParamSet 2: more effective relationships mean less relational domination.

Attachment-expansion, which is the probability that nodes form additional connections beyond those formed immediately upon entering the network in my model, has an indirect correlation with total agents, especially for ParamSet 1. I find a similar but much slighter correlation for ParamSet 2, which showed a high level of stochasticity at lower increments of the parameter. On the other hand, and perhaps unsurprisingly, for both ParamSets 1 and 2, attachment-expansion has a direct correlation with the average degree network metric – since all institutions try to expand their number of connections. This parameter does not have any pronounced effect on the maximum degree metric, but for ParamSet 1 there is some slight direct correlation. Attachment-expansion is relevant for my third sub-hypothesis (waste commodification – albeit in various innovative and creative forms – is the status quo solution to the problem of urban waste due to stabilising and expanding influences), especially insofar as its applicability to the appraised city-specific networks is concerned. I discuss such applicability in the latter half of this section while I further discuss all sub-hypotheses in relation to theory and results in Section 5.2. In general, more intensive networking activity appears to correlate with a smaller number of total agents in any given network – especially if other factors at play do not have any major influence. The average degree network metric directly correlates with attachment-expansion, and this may reflect contemporary social networks facilitated by information and communication technologies

(Borgatti et al., 2009). This begs questions about the meaning of connectedness and about the outcomes that might result from disparities in connectivity (Barabasi & Albert, 1999). In that respect, the effect of my attachment-expansion parameter is ambiguous: for ParamSet 1, the maximum degree has a slight direct correlation with it, whilst there is none for ParamSet 2.

Attachment-stability, which describes the resilience of existing connections between nodes, has an indirect correlation with total agents and a high level of stochasticity for ParamSet 2 at the lower increments of the parameter. There is a strong direct correlation with the average degree network metric for both ParamSets 1 and 2, with a moderate level of stochasticity for the latter. Attachment-stability has a strong direct correlation with maximum degree for ParamSet 1 and a weaker direct correlation for ParamSet 2. This parameter can be understood as a factor embodying the negative form of institutional work as the concept is applied to environmental governance by Beunen & Patterson (2019). That is, it can be understood as the anti-emancipatory form of institutional work which entails the active or passive maintenance of existing institutional arrangements (or dominance, in particular) (Beunen & Patterson, 2019). More concretely, in my critical understanding of institutions as necessarily dominating (Boltanski, 2011), this parameter can indicate an active perpetuation of domination. Indeed, such an interpretation is consistent with the influence this parameter appears to have on network metrics – especially if we critically consider its effect on average degree alongside the reinforcing effect it has on maximum degree, which may itself drive up the average degree. Of course, as Beunen & Patterson (2019) argue, systemic continuity in environmental governance is not necessarily a result of agentive interventions – nor is it intrinsically undesirable in all contexts. However, together with the consistent but metamorphous presence of critical statements in my interviews with institutional representatives actively partaking in the real waste governance networks I studied, I find it difficult to agree that the absence of change is random or accidental in this sense. My position in this regard is reinforced by Allouche et al. (2019) and Fraser & Jaeggi (2018), all of whom argue that there is active resistance to deep institutional change related to capitalist logic. A more detailed assessment of this dilemma is provided in the section that follows (Section 5.2).

Disruptor-probability, a probabilistic function which determines the likelihood of nodes coming into the network despite the relevant waste-type being adequately "handled", does not have a major effect on any of the measured network metrics. However, it does have a minor direct correlation with maximum degree with a moderate level of stochasticity. It is interesting to note that in terms of total agents and average degree, there are significant differences between ParamSets 1 and 2, although this is likely attributable to the two respective (mid-low and mid-high; Table 8) combinations of other parameters which were kept constant during this simulation

series. Again, without pre-empting the remainder of this section where I deal with the explanatory part of my ABM, disruptor-probability has been a key factor in the configuration of parameters to grow networks matching those I studied in combination with their relevant Scenario Settings.

At first glance, it seems elimination-probability (which can be thought of as the opposite of disruptor-probability in that it sets the probability of an institution being eliminated once its corresponding waste-type has been handled by the network) has a similarly negligible effect on all of the network metrics, again with the exception of maximum degree (albeit with an indirect correlation). However, upon closer inspection it has a slight effect on both total agents and average degree. Elimination-probability indirectly correlates with both, with total agents being more sensitive to it for ParamSet 2 and average degree more sensitive to it for ParamSet 1. The relative importance of disruptor-probability versus elimination-probability is interesting because, on the whole, the latter is more effective in terms of measured network metrics. Furthermore, whilst its slight indirect correlation with total agents and average degree might be interpreted negatively using the value judgement I set out earlier in this section, its effect on maximum degree is however both stronger and more desirable. The insecurity of domination, or potential for emancipatory institutional change is, in other words, more closely correlated with the potential for ejection of the old – rather than injection of the new.

The final parameter to discuss in terms of my sensitivity analysis is elimination-exponent. This parameter, being one of the few applying only to a subgroup of nodes or institutions in the overall network, sets the level of resistance to elimination actively exerted by the dominators – or the most connected nodes in my model design. For both ParamSet 1 and 2, this exponential factor shows a slight indirect correlation with the total agents network metric. Surprisingly, it also has a slight direct correlation with average degree – meaning the average connectedness of the network increases as dominant institutions' resistance to displacement increases. This is especially apparent for ParamSet 2. And, whilst a high level of stochasticity applies to this observation, elimination-exponent does not correlate in any remarkable way with maximum degree. As with certain other parameters, elimination-exponent is more pivotal in the process of calibrating the model in line with city-specific Scenario Settings to grow networks that best fit those I observed using SNA (in terms of the selected metrics I have discussed here at length). Still, there may be some theoretical value to be drawn from the apparent relative irrelevance of this parameter in directly influencing measured network metrics. Firstly, it is important to consider structural or system-wide dynamics of networks rather than focusing solely on individual factors. And, secondly, there is a need to critically consider the widely welcomed outcome of integration in environmental governance systems, especially if active dominance fosters it (Koch et al., 2021).

In general, Table 9 (p. 123) shows that attachment-stability has a relatively strong effect on all network metrics. Attachment-expansion strongly affects the total agents and average degree network metrics, whilst capacity-link-influence has a relatively strong effect on total agents and maximum degree. Attachment-idolization has a relatively strong effect on the maximum degree metric. And elimination-exponent has a relatively strong effect on the average degree network metric. Whilst these dynamics may be consequences of my model design and the theoretical framework which informed it, the primacy of these parameters is suggestive of relational-ideational power in waste governance propelled by the institutionalisation of CE and FEW nexus ideas. Yet, upon closer inspection as illustrated in my discussion above, apparent trade-offs emerge between what I consider to be desirable versus undesirable effects on network structure – even as a function of a singular parameter alone (all else being equal). This is an important finding with respect to complex and heterogeneous contexts of contemporary governance in cities, especially when said contexts account for the proliferation of information and communication technologies through which power in ideas is accumulated and exerted. That is precisely what achieving my research aim requires since it considers the institutionalisation of CE and FEW nexus ideas, observed through digital media, as its empirical point of departure. The apparent indeterminacy we might associate with such complexity is amplified when we also consider the contingency that comes with contemporary waste governance networks, as I have conceptualised them in this research, in specific places at specific moments in time. Below, I discuss results of my attempt to do this by extending my ABM method.

City-specific and explanatory agent based modelling and comparative case study results

The calibration of my model to reproduce networks with matching metrics relative to city-specific Scenario Settings was informed by my SNA results and the model dynamics I discussed above. What follows is thus a discussion of the results presented in Section 4.3.2 in combination with those presented in Section 4.3.1; situating all of this in the broader theoretical framework laid out in Chapter 2 before I discuss my hypotheses and contribution to the theory in the remaining subsections of Chapter 5 and finally conclude in Chapter 6.

For ease of reference, Table 13 (p. 132) contains the results I discuss below. Overall, the Scenario Settings remained constant. This means that the proportion of waste types in the respective governance networks were kept constant during simulations, as were the relative proportions of institution types (Section 4.1). Probabilistic functions include attachment-affinity, attachment-expansion, attachment-stability, disruptor-probability, and elimination-probability. Exponential functions include attachment-idolization, capacity-link-influence, and elimination-exponent.

I begin with probabilistic functions. Rotterdam shows the lowest attachment-affinity by a wide margin, set at 15, compared to the same function set at a mid-range of 50 and 55 for Bristol and Cape Town respectively. In colloquial terms, attachment-affinity can be seen as the insularity with which institutions in waste governance networks relate to others, *i.e.*, to what extent there is a higher likelihood of relationships within a sectoral sub-category than across sectors. As I noted earlier, that is why this parameter is antithetical to the FEW nexus principle of cross-sectoral collaboration – or the affinity to others who are not the same. Thus, my findings indicate that FEW nexus ideas are highly ingrained in the structure and composition of Rotterdam's waste governance network where networking seemed to be indiscriminate in terms of waste-type or nexus-type institutional profiles. This result may be skewed by the relatively high proportion of "other" institutions in Rotterdam. Probabilistic factors of 50(%) for Bristol and 55(%) for Cape Town are ambiguous. This is surprisingly high in Bristol's case because the SNA data collection and analysis process suggested a strong discursive trend suggesting that FEW nexus ideas are institutionalised to a relatively high degree. In contrast, this is surprisingly low for Cape Town because the qualitative data collection and analysis processes did not suggest a discursive trend wherein FEW nexus ideas are institutionalised, and I find only tangential reference to CE ideas. An alternative interpretation of this finding may be that it reflects differences between cities in how biased the discursive utilisation of either FEW nexus or CE concepts is – and perhaps even differences in its general authenticity. There may also be an important temporal element to this finding: the discursive utilisation of these concepts is arguably at different levels of maturity across respective cities. Also, local governments in each case relate differently to dispensations at higher levels in terms of the CE and FEW nexus: there are policy-, political-, and fiscal divides. In both regards (temporal and political alignment between local and broader dispensations), this line of argument would suggest that Rotterdam's network is both more mature and more aligned.

Rotterdam has the lowest attachment-expansion by an even wider margin at 24(%), compared to 75(%) and 65(%) for Bristol and Cape Town respectively. As seen in Table 13, the only other parameter which shows the same relative calibration (Bristol highest, Cape Town middle, and Rotterdam lowest) is capacity-link-influence. This brings into question the relative pragmatic import of networking activity; how and whether relationships matter where, when, and for whom. This finding resonates with my abductive-retroductive approach to analysing qualitative results and with my conceptual framing's emphasis on context (Cabrera & Cabrera, 2018; Tikly, 2015). By this logic, it seems there is relatively high importance associated with networking activity for Bristol's waste governance and slightly less importance associated with the same activity in Cape Town – whilst negligible importance seems to be attached to networking activity in Rotterdam. It is worth noting that these relative configurations correspond with my assessment of the relative

degree to which critique has become a common phenomenon in the governance networks. Again, there may be an important temporal element to this finding insofar as CE and FEW nexus discourses and their relevance in networking activity have taken root and lost their radical edge.

Bristol showed the lowest attachment-stability at 77, not far below Cape Town's 80 but well under Rotterdam's 96. This parameter has one of the most consistently high probabilities across all three cities under study. Understanding this parameter in the more agentive sense, by for example attributing it to active institutional work undertaken by dominant institutions (Beunen & Patterson 2019), suggests extremely secure domination in Rotterdam, strongly secure domination in Cape Town and near equivalently strongly secure domination in Bristol. And, by extension, since the observed networks I sought to emulate in this final phase of my ABM method are characterised by ideational alignment with either CE and/or FEW nexus ideas through the world wide web, this suggests that the level of opportunity for the exertion and maintenance of power in these ideas is extremely high in Rotterdam, very high in Cape Town, and high in Bristol. This means, in my reading and critical application of Carstensen & Schmidt's (2016) notion of ideational power, that imaginaries of alterity are relatively subject to restriction in the same descending order in each respective city. Further then, the existence and effectiveness of emancipatory visions for waste governance in Rotterdam is expected to be lower than those in Cape Town and especially Bristol. The stability of this relative ideational-relational power implies that its force manifests *over time*. Thus, the absence of emancipatory institutional change is a phenomenon which gains momentum, and, in this more structural sense of attachment-stability, passivity can lead to tangible outcomes. In other words, structural factors are cumulative and therefore a lack of agentive intervention can compound the difficulty of further (and emancipatory) agentive intervention in the future. Specifically, if there are not active attempts to alter the structure of waste governance networks, institutional structures can be expected to become more and more difficult to alter over time. The relative configurations of attachment-stability are opposite to my comparison of the extent to which critique has become a commonplace activity in the respective cities' governance networks.

Disruptor-probability, *i.e.*, the probability of new nodes emerging despite waste-handling saturation, shows considerable variance between cities, with Bristol being the lowest at 40, Rotterdam at 60, and Cape Town at 90. I find no parallels to the relative disruptor-probability with regards to my findings of critique's prevalence or the structure of the real waste governance networks I appraised with SNA. There is, however, a similarity of relative network metrics (see Table 5 on page 93). Specifically, the appraised waste governance network of Cape Town has the highest number of total agents, Rotterdam the second highest, and Bristol the lowest. The same goes for maximum degree. This is challenging because the sensitivity analysis whose results I

discussed earlier in this section (Section 5.1.3) do not suggest that disruptor-probability has an independently strong effect on either the total agents or maximum degree network metrics – all else being equal. But, in reality, all else is not equal. To help me explain and interpret this result I turn to the compositions and contexts of appraised networks, which informed Scenario Settings. In material terms, the populations and concomitant volumes of waste vary significantly between cities (see Table 7; p. 109). The relatively large size of Cape Town correlates with the relatively high level of disruptor-probability, as does the large size of its informal sector or un-institutionalised and unregulated waste governance network (Perez, 2017). Rotterdam is also relatively large, but the scale of its population and concomitant volumes of waste correspond more closely to that of Bristol. Yet, there is a significant qualitative difference between the apparent relations between government and business institutions involved in the governance of waste in each city – not to mention the exceptional dominance of businesses and the entrepreneurial culture in Rotterdam. Said difference, I find, is a collaborative (Bristol) versus a competitive (Rotterdam) relationship. Bristol's relatively low disruptor-probability is unsurprising if we interpret the parameter in the capitalist sense of the term "disruption". The nature of the parameter in my model design is also worth consideration. I construed it as the probability of new institutions entering the network despite the relevant type of waste already being handled. In that sense, Bristol's vibrant third sector "industry" of ideational power around waste governance might be reflective of *dematerialisation*. In contrast, the financial value and government control of waste in Cape Town is consistent with a material/physical focus in its waste governance – which does not yet effectively govern waste in practice. Again, however, the temporal question regarding different levels of maturity in the way CE and FEW nexus concepts are being utilised in each case may also be relevant. Likewise, the relative alignment between local and broader dispensations may relate to differing disruptor-probabilities across cities. Cape Town's unique socioeconomic issues may, however, be why it has a slightly higher disruptor-probability – change is actively pursued.

Elimination-probability is remarkably low across all cities under study, with Rotterdam set at 5, Bristol set at 30, and Cape Town set at 15. These relative parameters (inversely) match my assessment of the relative potential for emancipatory institutional change in waste governance networks in the respective cities, which may be relevant for their capacity to alleviate social-environmental challenges (Section 5.1.2). That is, in my assessment based on relative levels of *effective* critique, Bristol shows the highest level, followed by Cape Town, and then Rotterdam. This may be related to the finding which I discussed in both Sections 5.1.1 and 5.1.2: contextually variable nexuses of financial and political control or forms of business-government domination. Here, the emphasis on relative potential for *effective* critique is the key point – since, as I have argued up to this point, there are indeed strong indications of critique which emanated from my

qualitative findings. Yet, the constellation of ideational power and its structurally and compositionally variable institutionalisation means that the impact of any form of critique is contextually variable. In terms of elimination-probability, I argue that the relatively high setting for this parameter in Bristol reflects its distinct institutional hybridisation as well as its strong constituency of third sector institutions which are proximate to those business and government institutions whose relations embody domination. There is, however, scope for their elimination. In Cape Town, such network relations are dominated by a government (whereas the balance of power in Bristol is not obvious) that is subject to public scrutiny and electoral disenfranchisement – hence there is *some* scope for elimination – but it is offset by the institutionalised extension of government's ideational power to hybridised quasi-governmental entities. And, in Rotterdam, the scope for elimination of comfortably dominant businesses is particularly low in the context of an ideologically aligned non-interventionist local and national government, and an apparently absent third sector. Whilst there is considerable critique flowing from academia and national government – it is difficult to give credence to its *effective* value in such a stabilised institutional arrangement.

Moving from the probabilistic to the exponential functions, the capacity-link-influence determines the degree to which connectivity or entrenchment in the networks influences capacity. As with attachment-expansion (in terms of relative settings between respective cities), the capacity-link-influence is 0.1 for Rotterdam (lowest), 0.2 for Cape Town (middle), and 1.1 for Bristol (highest). However, "capacity" in my model design is specifically representing the material-technical capacity to deal with or "handle" a certain quantity of certain types of waste as a function of relationships. Again, the relative magnitude of capacity-link-influence for each respective city mirrors my assessment of the relative prominence of critique. But, importantly, my assessment of the associated potentials for institutional change which can alleviate social-environmental challenges and deliver emancipatory outcomes does not mirror this relative magnitude. I discuss this crucial finding in more detail when I critically consider my hypothesis and my contribution to theory in the next section (Section 5.2). For current purposes, I argue that capacity-link-influence can be thought of as the extent to which the conceptual crux of governance theory has manifested itself in the respective waste governance systems of each city under study (Rhodes, 1997; Kooiman, 1999). And, whilst it is tempting to think of a higher capacity-link-influence, and thus a clearer manifestation of a system of resource control and allocation which does not appear to be anchored in a single institutional centre of ideational power, as desirable – we should remain mindful of warnings about the associated risk of a deficit in transparency, authenticity, responsibility, and accountability (Rhodes, 1997; Kooiman, 1999). In terms of my overall research design, capacity-link-influence can be thought of as an indication of relative discursive consolidation, or institutionalisation, of power in CE and FEW nexus concepts.

Yet, attachment-idolization (level of preferential attachment to the most connected, or incumbent, institutions) showed the opposite relative magnitude across cities with Rotterdam set at 3 (again, this is an exponential function with 3 being the maximum of the setting's range), Cape Town set at 2.7 (middle) and Bristol set at 2.6 (lowest). The difference between these is not as pronounced as those for capacity-link-influence. This is an affirmation of Barabasi & Albert's (1999) argument that any kind of (generic) network – whether it is computational or sociological or physical – tends to develop with two key drive forces: growth and preferential attachment. Attachment-idolization here represents preferential attachment in waste governance networks, and this setting is very high across all cities. Notably, Barabasi & Albert (1999: p. 8) argued that inclinations to preferential attachment and expansion might help explain the causes of social and economic asymmetries of power *in competitive systems*. In terms of my findings, despite apparently divergent competitiveness across city-specific waste governance systems or networks, this consistently high attachment-idolization might be indicative of strong competitive elements across contexts – manifested in different forms of institutional work (Beunen & Patterson, 2019).

Elimination-exponent, which represents the magnitude of resistance to elimination exerted by dominant institutions, is set to the maximum of 3 in Rotterdam, still rather high at 2.2 in Cape Town, and somewhat lower at 1.4 in Bristol. Thus, the relative magnitude, or at least the order of magnitude, between cities is akin to that of disruptor-probability and attachment-idolization. The variance between city-specific elimination-exponents is larger than is the case with their attachment-idolizations. I associate this parameter with my reading of critical institutionalism theory, which I emphasise for the remainder of this discussion in Chapter 5. At a glance, I ascribe the difference between these elimination-exponents to overall compositional and structural divergences between city-specific waste governance networks. As indicated earlier, relationships matter in Bristol – and they seem to matter significantly less in Cape Town and Rotterdam. The average institution in Bristol is more likely to be well-connected in its rather dense and small governance network. And, relative to obvious and seemingly resilient forms of institutionalised domination in Cape Town and Rotterdam, the degree to which critique or ideational dissent seems to have become a mainstream feature of waste governance processes is high in Bristol.

The elimination-exponent is perhaps antithetical to the potential for emancipatory institutional change. But this is complex. As I stated at the end of Section 5.1.1 and the start of Section 5.1.2, the depth and meaning of change in the waste governance networks is contextually variable, and there is a lack of corresponding variance in i) the relative degree to which critique or ideational dissent seems to have become a mainstream feature of waste governance processes, and ii) relative levels of apparent potential for emancipatory institutional change across the cities. What we are

confronted with in these findings, I argue, is an imperative to formulate a nuanced understanding of the manner in which dominant institutions exert resistance to their elimination. Such a formulation forms a crucial part of the penultimate sections that follow, wherein I attempt to utilise my overall findings in theorising some processes and outcomes of urban waste governance.

5.2 Hypotheses & contribution

In this section, I synthesise findings in earlier sections by drawing results together to address three sub-hypotheses alluded to in Section 1.7. For reference, my overarching hypothesis is that there is a divergence of political tractability between the CE and FEW nexus concepts, on the one hand, and radical critique of mass-productive and -consumptive behaviours on the other hand. I further hypothesised that this divergence can be causally related to the notion that urban waste governance systems comprise highly interconnected social structures through which strong institutions wield and mobilise power in ideas – and thus maintain their dominance and the status quo of waste commodification. Three specific sub-hypotheses stem from this. They are as follows:

1. Highly interconnected social structures constituting urban waste governance systems foster conformity to ideational power in circular economy and food-energy-water nexus concepts.
2. The mobility of, and the power in, capitalist ideas imbued with scientific and pragmatic authority restricts solutions for the problem of waste in cities to adaptive commodification.
3. The evolution of institutionalised urban waste governance systems, as diversifying networks of waste commodification, is mainly influenced by stabilising and expanding factors.

I address each of the respective sub-hypotheses in their own sections, starting with sub-hypothesis 1 in Section 5.2.1, sub-hypothesis 2 in Section 5.2.2, and lastly, sub-hypothesis 3 in Section 5.2.3.

5.2.1 Structure, composition & conformity

Earlier in this thesis, I hypothesised that highly interconnected urban waste governance systems foster conformity to certain ideas imbued with scientific and pragmatic authority. Specifically, I postulated that the circular economy and the food-energy-water nexus are examples of such ideas.

Using my social network analysis, which was specifically designed to appraise the structure and composition of urban waste governance systems in terms of their discursive natures, I measured the apparent interconnectivity of waste governance systems in Rotterdam, Cape Town, and Bristol. Using my qualitative analysis, I investigated and critically analysed the role of ideational power in processes of institutional change in these urban waste governance systems. Then, in my qualitative analysis, I reflected on some characteristics I identified using social network analysis. Taken together, these two methods provide key insights as to what the structure and composition of urban waste governance systems are, as well as why these attributes may have certain

qualitative causes, corollaries, and outcomes. For example, the dominance of businesses in a relatively large and clustered network comprising the institutional fabric of Rotterdam's waste governance system has its qualitative corollary in a strong alignment between local and national governments in terms of (pro-business) FEW nexus and (especially) CE discourse – with laissez-faire or limitedly emancipatory visions of CEs predominating in Rotterdam as a consequence. Using agent based modelling, I attempted to synthesise formative factors and simulate how these appeared to correlate with certain outcomes under certain conditions which varied contextually.

In keeping with my analytical frame of systems thinking and my conceptual frame of context in the interaction between research and government policy, I crafted the mixed method methodology outlined above as directly informed by an interdisciplinary theoretical frame. The combined application of my theoretical and methodological frameworks indicates that the structure of urban waste governance systems is network-like and that these networks have institutionalised asymmetries. In both respects, however, I find salient contextual variances between the respective cities. The scope and findings of my study reveal that these systems' network-like structures have strong discursive or ideational elements in their essential substance. This substance is real and effective (Larsson (2018) quoting Hay (2002: p. 103)). This matters in light of the real and impactful global social-environmental challenges urban waste governance systems are trying to alleviate. I concur with scholarly assessments which argue that there is an "*intimate relationship between power and knowledge*" (Larsson, 2018, p. 327), but findings suggest that the inherently heterogeneous and contingent waste governance systems here are not *fundamentally* changeable.

My findings align, rather, with arguments that the inherent diversity and tentative contextuality of social systems undergoing institutional change are characterised by asymmetries of influence and power – precipitating in *shallow* (as opposed to fundamental) transformation (Boltanski & Fraser, 2021). This is my own argument based on my findings, rather than a direct excerpt from Boltanski & Fraser (2021). My argument is merely strengthened by their more general argument that critiques of capitalism still operate but fail to bring about deep transformational effects. In my own assessment, the distinction between shallow and deep transformation is that the latter is characterised by permanent and major structural and compositional rearrangement. Specifically, such rearrangement would be emancipatory – meaning historical asymmetries of power would be diminished / neutralised rather than reformed. Relevant to such asymmetries, I argue, are apparent divergences in the degree to and manner in which critique has become a mainstream feature of urban waste governance processes. To justify my disagreement with the assumed durability of certain discourses, I have adopted a quasi-reified notion of institutions which cuts across regulatory, semantic, and material meanings (Boltanski, 2011). Such a notion is intertwined with

a pessimistic take on what institutions do: they overtly dominate the scope of scrutiny, policy, and practice (Boltanksi, 2011). Across the varying city-specific structures and compositions of urban waste governance networks – which my results specifically indicate are variable in their interconnectedness – critique has differing effects on policy and practice. In Bristol, which is the most interconnected case in my comparative study, there seems to be a relatively high level of institutional diversity and a discursive alignment with the FEW nexus concept. Yet, here I find the most mainstream critique – albeit limited in its potential emancipatory impact – due perhaps to the very fact that such critique emanates from institutions which already appear to dominate the governance system. There is an important jurisdictional element in the interplay between structure, discourse, and conformity to an apparently emancipatory and already ongoing process of institutional change. That is, despite the endogenous asymmetries I identified in my SNA and which interviewees in Bristol confirmed, the targets of critique are exogenous forms of regulatory domination limiting the perceived depth of behavioural change. The semantic dimension of Bristol's waste governance network seems unbounded; and thus, the high interconnectedness of said network does not in fact foster conformity to my critical reading of CE and FEW nexus ideas.

My findings for Bristol thus falsify my first sub-hypothesis. But this is not a universal finding. The specificity of my findings in Bristol may be ascribed to its distinctly high level of mainstream critique in the existing institutional arrangement comprising its waste governance system (Lilja & Vinthagen, 2014). Perhaps shedding light on the ongoing debate about what role voluntarism and individual agency play in processes of institutional change, Interviewee I (2021) explicitly critiqued national government's waste governance policy regime for its excessive reliance on voluntary behavioural change. This, it was said, is not quite sufficient. That is because, in a hermeneutically liberal regulatory landscape I find in Bristol, dominant institutions have the freedom to interpret the rules guiding (rather than directing) waste governance in a minimalistic and diminishing manner. *This* constrains emancipatory institutional change. In the same vein, however, such a landscape also gives impetus to a vibrant third sector which could – through various channels enabling it to leverage the distinctively relational network which characterises Bristol's waste governance – grow and maintain its relevance in a discursive way. Adding to this its typically governance-like network structure (with a relatively high average degree and low maximum degree) – there are difficult questions about where responsibility lies. Rhodes (1997) and Kooiman (1999) identified authenticity and accountability as key imperatives for interlinked and interdependent governance systems in complex, diverse, and dynamic contexts. Such questions about responsibility, authenticity, and accountability are beyond the scope of my research, but it can inform future research directions.

In this section, I turn now to the findings for Rotterdam and Cape Town to qualify the falsification of my first sub-hypothesis in relation to Bristol, and to argue that this falsification is not quite universal. In the first instance, both of Rotterdam's and Cape Town's waste governance systems are less interconnected and larger, *i.e.*, comprise a larger number of discrete institutions. Both cities have relatively high maximum degree network metrics, which indicates that some institutions are extremely well-connected, and many others are not at all. The third sector component of Rotterdam's waste governance network is virtually non-existent, whilst that of Cape Town seems to operate cautiously and un-contentiously. In the former case, businesses comprise more than three quarters of the total institutional profile. In the latter case, businesses comprise a substantive proportion of the total institutional profile but appear to be rather peripheral to a central network anchored in local-provincial government. In both cases, the waste governance networks typify the growth of and preferential attachment to dominant institutions – irrespective of the origin of such domination. These are elements which Barabasi & Albert (1999) identified as being key features of large, "scale-free" random networks and the way they develop. It is important to note my finding that a key difference between Bristol, on the one hand, and Cape Town and Rotterdam on the other hand is that the latter two seem to be much more competitive. Rotterdam's competitive and entrepreneurial waste governance network is evidenced by both my SNA findings (businesses compositionally dominate) and qualitative data affirming it as such. Cape Town's competitive and highly politicised waste governance network is less apparent, since the relatively fragmented and discursively heterogeneous structure and composition can arguably only be understood with some qualitative data critiquing government's active domination.

The relative levels of critique in the urban waste governance processes of Rotterdam and Cape Town differ. In Rotterdam, representatives of institutions with considerable executive potential are (self-) critical of the fact that CE implementation may not deliver emancipatory change. A representative of Rotterdam's national government, which has supreme regulatory authority, verbalised such self-targeting critique without addressing commercial dominance. In Cape Town, more radical critique of current institutional arrangements which are mutually exclusive to emancipatory CE implementation are directed at local and provincial governments, suggesting that active resistance to emancipatory institutional change is the challenge. These observations inform my assessment that critique is relatively more mainstream in Cape Town, but the essence of my finding is that the potential emancipatory institutional change is similar (low). Indeed, the enunciation of critique conforms to the power in the CE semantic vehicle, or idea. In this sense, findings from Rotterdam and Cape Town confirm and validate my first sub-hypothesis. Yet, such conformity does not correlate with relative interconnectivity of the governance networks. Instead, I attribute said conformity to structural *and* compositional domination embodying capitalist ideas.

5.2.2 Power in ideas & restricted imaginaries of alterity

In order to qualify my explanation of the apparent divergence between the respective cities, or at least between Bristol on the one hand versus Rotterdam and Cape Town on the other hand, in terms of their conformity to the power in CE and (to a significantly lesser degree) FEW nexus concepts, I revert to my critique of CE and FEW nexus literature in Sections 2.1.1 and 2.1.2. I do so with reference to (critical) institutionalism literature in Section 2.2.2 and qualitative data in Section 4.2. Much of the discussion in this section is based on interview data presented in Section 4.2. Earlier, I hypothesised that the mobility of, and power in, capitalist ideas restrict conceivable solutions for the problem of waste in cities to adaptive commodification. Specifically, and following directly from the qualification which I first set out below, I construed CE and FEW nexus ideas as cases in point: as mobile capitalist ideas (they are rapidly being mediated by new information and communication technologies) imbued with scientific and pragmatic authority.

Influential governments and businesses have been implementing the popular CE, which is understood as a set of changed consumption and production activities emphasising optimisation (Parsa et al., 2021). My critical readings of some relevant CE and critical institutionalism literature led me to an unconventional understanding of the CE as a seemingly innocuous semantic vehicle or rhetorical instrument. Crucial issues such as social reproduction and equity are neglected by a purely material-technical approach to the challenge of waste in cities; but the institutionalisation of CE ideas in urban waste governance networks matters for the construction of social reality and the distribution of political entitlements (Vira, 1997; Boltanski, 2011; Mavropoulos & Nilsen, 2020). When combining my readings of what the CE seems to be about if it is uncritically considered in technical terms (optimising technical-material activities of consumption and production in a context of environmental degradation) with what the institutionalisation of ideas like a CE might mean if it is critically considered in the context of a social-economic system (defining a distribution of social-political endowments in a context of economic inequality and democratic recession) – a contradiction emerges. Increasingly, therefore, critical reflections of the CE as a semantic phenomenon are forthcoming (Cowell et al., 2020; Temesgen et al, 2021). Cowell et al. (2020), for example, critically analyse the simultaneous mobilisation of "civic" and "market" logics by dominant institutions' agents, pursuant to the stability and continuity of international regulatory harmony: to protect the trade of valuable recyclable wastes across national borders. Temesgen et al. (2021) argue that in order to solve the interrelated and global social-economic-environmental challenges we face, ontological questions must be asked and answered in conjunction with the institutionalisation of CEs. I agree. In the sections below, I attempt to provide at least some tentative answers to such ontological questions.

As a step forward, I foreground the imperative of critique in asking and answering such questions. And as Temesgen et al. (2020) point out, there are axiological issues to be addressed – questions about what we value and why. This is conceptually akin to the imperative of evaluative learning in waste governance which I have argued for throughout this thesis – an exercise which Vira (1997) crucially points out is laden with value judgements that should be made explicit and transparent. Turning to my results, it is necessary to reiterate that the degree to which critique has become a mainstream feature of waste governance processes is most pronounced in Bristol. However, the (primarily) CE and FEW nexus ideas featured more strongly in the enunciation of critique when I engaged institutional representatives from Rotterdam and Cape Town. This runs counter to the relative extent to which CE and FEW nexus ideas have been institutionalised in each city's online waste governance network – which I used to identify and analyse relevant institutions. CE ideas seem to be deeply ingrained in Rotterdam, and FEW nexus ideas seem so in Bristol. Neither of these ideas seem to be ingrained in Cape Town's online waste governance network. I find a lack of corresponding variance in the potentials for emancipatory institutional change (versus variable degrees and kinds of criticality and CE/FEW nexus institutionalisation). I interpret the finding in this way: my second sub-hypothesis holds, and I theorise that this is what explains the lack of corresponding variance in the potential for emancipatory institutional change.

Against quite different compositional backgrounds of institutional domination in Rotterdam and Cape Town (see Figures 7, 8, 11, 12, and Table 14), critiques of the current urban waste governance system are promoting the mobilisation of (mostly) CE and FEW nexus ideas in conjunction with critical statements about the role of money and its problematic proximity to political power. In Rotterdam, business domination (and the logic of commodification this implies) is not the object of critique – rather, there is academic and national governmental critique of missing regulatory intervention that could *destabilise* existing linear economies. Data suggests that if such regulatory intervention occurs, assuming that the imaginary of alterity it brings to bear is its antithesis, policy change would create constructive chaos and destabilise existing supply chains for a more fundamental transition to the CE. In Cape Town, strong regulatory control of waste governance does not yield the sort of emancipatory institutional change interviewees desire. Indeed, there, regulatory control constitutes an antithesis and so, if regulatory intervention is diminished or eliminated, government would reduce its role and allow the private sector to deliver a fundamental CE – which necessitates fundamental change in local government itself. But, in Bristol, interviewees express a different vision toward neither a CE-style nor a FEW nexus-style waste governance system, but toward something else entirely. Qualitative data thus suggest, to my mind, that the (capitalistic) ontological significance of these concepts has already undergone a distinctly advanced process of evolution in Bristol – and that there is some critical awareness of

this. Over and above the obvious meaning of the longstanding political dominance of the Labour party in Bristol, one interviewee attributed the unconventional institutional make-up of Bristol's waste governance network to a "*quite alternative*" or "*anti-establishment*" culture. However, the antithetical "establishment" seems to be widely understood as something external to Bristol itself, and this perception appears to consolidate distinct cohesion and critique's mainstream role here.

Yet, the potential for emancipatory institutional change in Bristol's waste governance network does not seem meaningfully greater when compared to that in either Cape Town or Rotterdam. Despite the divergences in the force and form of critique characterising each case, my findings suggest that the effect of fundamental change in regulatory and practical norms remain elusive. This finding aligns strikingly closely with the argument advanced by Boltanski & Fraser (2021). Taking a purposefully and explicitly holistic approach to our *general* social-environmental crisis, Boltanski & Fraser (2021) argue that the main barrier to fundamental institutional change is the ineffectiveness of critique, especially when capitalism is the target. Boltanski & Esquerre (2017), in critiquing commodities, elucidate the diversifying ways in which capitalism's logic manifests. Relating this to the context and findings of my research, consider my earlier point that the systematic exercise of ideational power – even in the realm of environmental (and even more specifically, waste) governance in cities – is an industry in itself. Critiques of domination in the waste governance network of Bristol illustrate my argument. Such critiques are mainstream, so much so that some institutions make its production and mobilisation a key part of their operations. For example, Interviewee E (2020) (representing a key institution in Bristol's waste governance system identified in my SNA) stated that "*collaboration, policy, and lobbying*" has become a key part of their work – as opposed to purely material-biophysical operations. Ideas (about waste) are commodified. Advancing Boltanski & Fraser's (2021) point, I argue that some dominators have not only come to *tolerate* critique but have come to *incorporate* it and make such incorporation part of a process of discursive consolidation ushering in the capitalist logic of commodification. Such a "business of critique" cannot be denounced entirely, however, since the virtue or potential for emancipatory institutional change which accompanies radical critique of domination loses its force if it only originates from representatives of institutions which remain marginal in networks. This challenging balancing act between entering and forming part of asymmetrical urban waste governance systems to gain power, on the one hand, and advancing radical critique that might bring about emancipatory institutional change may be akin to Nunes' (2017) "*pragmatist ethics*".

My contribution, based on findings that confirm my second sub-hypothesis, is an elucidation of how such nascent forms of "*pragmatist ethics*" are perhaps taking place in institutionalised urban waste governance. My findings do not precisely show that the *mobility* of, and power in, capitalist

ideas restrict conceivable solutions to the problem of waste in cities to commodification, but that it is the metamorphic and all-pervasive nature of the power with which they are imbued that undermines the emancipatory impact of critique (variable force and forms) on ongoing processes of institutional change within complex, diverse, and dynamic urban waste governance networks. The contemporary forms of governance which I have employed in my research are inextricably intertwined with the ever-expanding role that information and communication technologies play in facilitating and mediating the metamorphic and pervasive manifestations of capitalist ideas. Urban environmental and waste governance systems are no exception. To the contrary, the sheer complexity and ever-presence of change characteristic of cities everywhere are compounded by the interdependence of both the global social-environmental challenges and the local governance regulations, discourses, and practices which seek to address those challenges in a contextual way.

5.2.3 Stability, expansion, diversification & commodification

In this section, I synthesise all my findings against my third and final sub-hypothesis: that the evolution of institutionalised urban waste governance systems, understood as diversifying networks of waste commodification, is predominantly influenced by stabilising and expanding factors. The findings in this section include results from my full mixed methods methodology, as in the preceding sections.

The instructive finding I begin with in this penultimate section is the surprising appropriateness of combining Boltanski's (2011: p. 79) critical understanding of institutions as inherently serving a dominating purpose, on the one hand, and his expansive utilisation of the term "institution" in a "*quasi-reified fashion*", on the other. Firstly, I remind the reader of the analytical and conceptual value of a critical understanding by summarising my earlier arguments. My ABM results, as discussed in Section 5.1.3, indicate that ejecting the old matters more than injecting the new in terms of potential for actual emancipatory institutional change or effective critique of domination. Whilst I concur with Larsson's (2018) argument that we must be careful not to overestimate the import of intentional individual agency, I also reject the complacency of arguments which suggest that institutional arrangements are perhaps best left the way they are (Beunen & Patterson, 2019). My findings contradict arguments on the fringes of institutionalist literature suggesting that there is perhaps an excessive focus on processes *and* outcomes of institutional *change*, since such change may usher environmental governance systems from bad to worse (Beunen & Patterson, 2019). That is, my findings suggest that institutional change is indeed desirable since stability is a more pivotal factor in the determination of current waste governance systems than disruption. In particular, my ABM results show relatively high levels of disruptor-probability and relatively low levels of elimination-probability (see Table 13) in the observed urban waste governance networks. This means that, in these networks which my qualitative findings show are subject to

critique of various strengths and kinds, emancipatory institutional change remains wanting. Newcomers enter the system and fail to significantly change it, and dominators are not eliminated. Importantly, as I elucidated in Section 2.2.2 where I critically analysed critical institutionalism, emancipatory institutional change means effective erosion of domination in extant institutional arrangements or contexts (Boltanski, 2011; Wilmott, 2015; Lok, 2019; Boltanski & Fraser, 2021). Attachment-stability is relatively high across all three cities under study. The resilience of the studied urban waste governance networks keeps them stable, albeit in an undesirable status quo, thus undermining transformation into more socially just and environmentally sustainable systems.

In my third sub-hypothesis, I postulated that the status quo is one whereby commodification – albeit in various innovative and creative forms – is considered the supreme and intuitive solution to the problem of urban waste. I hypothesised that two predominant factors are establishing and maintaining said status quo despite important contextual dimensions of complexity, dynamicity, and diversity. These factors characterise the technologically mediated institutionalisation of governance networks in cities; they are forces favouring stability and expansion. Whilst attachment-stability appears to be a predominant factor in all cities under study, with some variation, attachment-expansion does not. This finding partly contradicts my third sub-hypothesis.

In both respects, Rotterdam appears to be the outlier. Its attachment-stability is higher than that of either Bristol or Cape Town, whilst its attachment-expansion is significantly lower than that of either Bristol or Cape Town. My triangulated findings suggest that commodification is, by some margin, most patently entrenched as *the* solution to the urban waste challenge in Rotterdam. However, if we take a closer look at the structure of respective networks in my SNA results, it seems that Rotterdam's network was as a whole more expansive in the sense that it comprised the largest number of total agents linked by a single, sprawling web of waste governance institutions. The sprawling aspect is important since this visually reflects the distinct difference between the most and least connected institutions characteristic of Rotterdam's waste governance network; implied in relatively high maximum degree and relatively low average degree network metrics.

Cape Town is even more extreme in the same structural regards (see Table 5). Compositionally, however, it is not. That is, businesses – operating on the tacit principle of commodification – neither compositionally dominate Cape Town's waste governance network to the same extent, nor in the same interconnected manner. Compositionally, Cape Town comprises a more diverse range of institution types. And, structurally, Cape Town's SNA results show an apparent disconnect between business cliques and the government dominated main governance network. The value attributed to an item (say, a unit of waste) "*may differ across 'form-specific' economies and across spatio-temporal contexts*" (Susen (2018) paraphrasing Boltanski & Esquerre (2017)).

Taking into account the relatively low level of transparency which appears to characterise important clusters of Cape Town's waste governance network, what I infer from these results are divergent regimes of discursive justification for the same dominance of commodification which characterises Cape Town and Rotterdam. In both cases, waste is assigned with monetary value – irrespective of the intricacies of such assignation (which may well be materially different in itself) – but the institutionalised social order exercising it differs significantly (Fraser & Jaeggi, 2018).

Here an important aspect of my interpretation of overall findings emerges: such differentiated patterns of institutionalised commodification (driven to various degrees and in various ways by the pervasion of capitalist ideas imbued with scientific and pragmatic authority, like the CE and FEW nexus) interact with existing social realities in a reinforcing cycle. If we consider, as I do, that our existing social reality is underpinned by interrelated global crises of economic inequality, environmental degradation, and democratic recession, then such a cyclical effect is problematic.

Rather than falsifying my third sub-hypothesis outright, the case of Bristol is perhaps the most compelling in that it confirms the *diversifying* and *adaptive* trajectory of commodification in urban waste governance networks I posited in both my second and third sub-hypotheses. With a *relatively* low attachment-stability and relatively high attachment-expansion, my findings for Bristol present a relatively small (low number of total agents or institutions), cohesive, and diverse waste governance network wherein, I argue, critique has become a common phenomenon. Nevertheless, these findings appear to contrast with my finding that i) there is low potential for emancipatory institutional change in Bristol, and ii) waste commodification has *dematerialised*. Consistent with and in contribution to literature suggesting that urban waste has become a new commodity frontier in South Africa, Europe, and beyond (Samson, 2020; Schindler & Demaria, 2020; Irvine, 2023), my findings suggest that waste commodification is transcending the physical and entering the realm of ideas. I attribute a (moderately) strong element of critique in Cape Town to an apparent schism which separates the somewhat diversified dominance of local-provincial government from businesses, as well as to emotive perceptions of injustice being perpetrated by a dominator advancing combined "civic" and "market" justifications (Boltanski & Thevenot, 2006; Perez, 2017; Cowell et al., 2020). And I attribute the relatively weak element of critique in Rotterdam to an apparent harmony that characterises the patent dominance of businesses in an urban waste governance network wherein a critique of the powerful CE idea seems to stem only from academia and national government. Contrary to Cape Town then, said combined public-private discursive justifications do not evoke similar ideational dissent or notional potential for emancipatory institutional change in Rotterdam. As to why, the findings of this research suggest i) the specific social-political-financial context, and ii) the profile of domination in Rotterdam.

Drawing to a close of this penultimate section, my findings suggest that my third sub-hypothesis is incorrect insofar as institutionalised dominance of waste commodification does not seem to be driven mainly by stabilising and expanding factors. Key drivers at play in the dynamic process of institutional change (or continuity) in urban waste governance are highly complex and diverse, and my findings suggest that principal importance should be ascribed to the metamorphic and all-pervasive nature of pioneering capitalist ideas imbued with scientific and pragmatic authority. This is perhaps a procedural emphasis, but the findings I highlighted in this section (Section 5.2.3) point to a similarly metamorphic nature of the structural and compositional outcomes that may result. Relating this to my first sub-hypothesis and relevant findings I discussed in Section 5.2.1, another important factor relates directly to the definition of "institutions" which I adopted in my research. The regulatory-*semantic*-material meaning comes into play when, as most usefully illustrated by the Bristol case, the relative degree of hermeneutic freedom with regards to waste governance regulations is considered comparatively and critically. The semantic emphasis I used in this study brings the imperative of responsibility and transparency into focus, especially if, like in Bristol, the regulatory environment is characterised by an expectation of voluntary behavioural change; or if, as in Rotterdam, the regulatory environment is conducive to disruption but not to elimination. In Cape Town, the imperative of responsibility and transparency is perhaps most pressing of all given its context of acute poverty and inequalities overseen by government – yet there is major dissonance between critical voices and decision-makers with emancipatory power. Further implicating the metamorphic and all-pervasive nature of pioneering manifestations of capitalist ideas in urban waste governance networks, local government seems to be consolidating an institutionally diverse grip on waste trade relations to capitalise on any future transformations.

5.3 Limitations

The purpose of this section is to discuss some of the limitations of my research which had the greatest potential impact on the quality of my findings, my ability to answer the research questions, and my ability to test the hypotheses. I discuss each limitation by identifying it, reflecting on it, and critically resolving it.

The first limitation was my emphasis on relational structure as a constitutive factor of urban waste governance systems. The second limitation was a small number of interviews, however, my prioritisation of those institutions which appeared to be the most well-connected in my SNA results in my qualitative analysis sampling compensated for that limitation. The third limitation was the predominantly electronic media through which I collected and analysed data. And, lastly, the demarcation of my generic ABM sensitivity analysis to network metrics reported in my SNA, and the high level of abstraction used in my model design, was the fourth limitation.

Emphasising relational structure as a constitutive factor of urban waste governance systems was a choice I made on the basis of two key motivations. The first was the notion of ideational power I opted to use (Carstensen & Schmidt, 2016). Generally, there is an intersubjective element to this notion of power. To illustrate, Carstensen & Schmidt (2016) departed from Hay's (2002: p. 185) definition of power as "*the ability of actors (whether individual or collective) to 'have an effect' upon the context which defines the range of possibilities of others*". Consequently, the specifically negative emphasis of power *in* ideas offered by Carstensen & Schmidt (2016), which I adopted in my research design, highlights the authoritative conceptual edifice or *tacit* frame of reference against which ideational novelties are evaluated by custodians of different types of dominant institutions. I emphasise the word "tacit" here because, hypothetically underpinning the overt semantic forms I used in my research (CE and FEW nexus ideas), was the reality of a depoliticised or unquestionable capitalism. Therefore, I saw fit not to emphasise individual intent as a potential constitutive factor of urban waste governance systems. The second motivation for emphasising relational structure was my reading of (environmental) governance theory. Combining the foundational works of Rhodes (1997) and Kooiman (1999) provided a distinctly relational concept of governance per se. This differs from "government" or "governing" in that linkages, and the networks which they form in aggregate, are crucially important for the exercise of regulatory authority and the determination of practice. Indeed, the interdependent or interactional dimension – and its salience – is juxtaposed to the traditional notion of governing insofar as the processes and outcomes of decision-making have become diffuse. This theoretical point of departure interacted with my choice of systems thinking as analytical frame and with my philosophical divergence from positivism insofar as empirical data was concerned. In terms of answering my first research question, as I alluded to in Section 5.1.1, these decisions, especially the focus on relational structure, made the structural aspect of my answer somewhat predictable (urban waste governance systems are network-like). Combined with my strong emphasis on two specific instantiations of power in CE and FEW nexus ideas, these choices also meant that some elements of the systems in question may have eluded my scope of analysis – not least of which being salient disconnected institutions. However, I offset this limitation by exposing the analysis to open-ended sources of data and a combination of computer based social science methods – thus accommodating data and systematic analysis that could contradict this limitation's assumptions.

That first limitation spilled over into the second, which was my prioritisation of engaging with well-connected institutions in a small number of interviews. This was ultimately a strength and a limitation. The demarcation of my SNA and qualitative analysis samples gave impetus to the second pillar of my theoretical framing: (critical) institutionalism theory. That is, the focus on dominant or well-connected institutions – which the first limitation I discussed above necessarily

implied – lent itself to a critical analysis. Representatives of key identified institutions were key informants who could speak to the wider context of their specific case study sites (*e.g.*, they had engaged widely with other knowledge holders and could hence present an expanded interpretation of their respective waste governance system). I utilised the different methods I employed by triangulating the primary data emerging from interviews with other, secondary data available for each case study. Using relational-ideational power (and specifically power *in* ideas as outlined above) as my point of departure serendipitously coupled with my conceptual framing of context in the interaction between research and government policy, which hence enabled me to address known gaps in both environmental governance and critical institutionalism. Thus, I mitigated the limitedness of excluding relatively disconnected or discursively non-conforming institutions from direct qualitative data collection and analysis by foregrounding the role of effective critique in constituting potential emancipatory institutional change in the urban waste governance networks under study. And I took the meaning of "emancipatory" institutional change as effective erosion of domination in extant institutional arrangements or contexts (Boltanski, 2011; Wilmott, 2015; Lok, 2019; Boltanski & Fraser, 2021). Domination of any ilk is therefore considered undesirable.

The third limitation is not unrelated to the first and second. What began as a practically motivated choice to delimit all data collection to electronic or digital media, most notably due to the restrictions on physical movement and interpersonal interaction caused by the global Covid-19 pandemic, ended up as an important contextual element of my overall research design. My concern was that this choice could be exclusionary and damage the thrust of my argument, especially with regards to my second research question probing the role of ideational power in emancipatory institutional change taking place in urban waste governance networks. However, thanks to the theoretical and conceptual frameworks I outlined in relation to the first and (especially) second limitations above, I was struck by the substantive coverage which digital or electronic media afforded my analysis. Indeed, the formulation of my second hypothesis partly depended on this limitation as the mobility of power in capitalist ideas could be catalysed by information and communication technologies. This bold hypothesis was supported by influential works, such as that of Bodin et al. (2019), which encouraged me to simultaneously postulate cross-contextual causal patterns and sensitise my methodological design to place-specific properties. Delimiting data collection and analysis to electronic or digital media thus facilitated a network-centric combination of methods comparing multiple, distinct city-specific contexts in a relatively consistent way – thus enabling theorisation.

The final limitation which had the greatest potential impact on my ability to test hypotheses and answer my research questions was the design of my ABM. In the dizzyingly wide range of

possible purposes and functions this method affords, I chose to delimit it in a manner that enabled me to triangulate my SNA, qualitative analysis, and ABM results throughout my overall methodological design. To anchor the final experimental aspect of said methodological design within my theoretical framing and in my SNA and qualitative results, I designed a model to extrapolate the frozen-in-time ("snapshot") networks and to show how they grow in structural terms. This was in keeping with my negative or critical analysis of the most well-connected or apparently dominant institutions: to see how they become and remain dominant in terms of measurable and comparable network metrics. As I described in Section 3.5.3, this final part of my methodological design incorporated theoretically significant elements of stochasticity (or agentive-randomness) and of dynamicity (temporality and the omnipresence of change, as I put it). That was especially applicable in the first modelling phase where I conducted a sensitivity analysis demonstrating the relative systemic import of contrived parameters. But the second modelling phase, where I sought to configure a "best-fit" of parameters which would reproduce a network with properties akin to that of the waste governance networks I had appraised using SNA, was limited in that the composition of networks remained constant during individual simulation runs. This may have impacted on my ability to meaningfully test my third sub-hypothesis insofar as it posited that these networks were "diversifying". However, I mitigated this limitation by building Scenario Settings into the model design – representing relative degrees of diversity between city-specific simulation series. It may also have limited my ability to answer the third research question insofar as the compositional outcome of institutional change in urban waste governance networks was concerned – since composition remained constant in simulations.

Yet, the limitations I highlighted above applied to singular parts of a mixed method methodology which was intentionally designed to offset known and probable weaknesses associated with each part. Thus, whilst there is a non-negligible possibility that said main limitations impacted on the quality of my findings, my attempts to mitigate associated risks appear to have proven effective and surprisingly fruitful. The plurality which my analytical framework of systems thinking was selected to accommodate manifested both in my interdisciplinary theoretical frame as well as in my methodological design. But most importantly, the complexity and contextual contingency of my subject matter ultimately made meaningful critique challenging. The institutional nebulousness of waste commodification in urban environmental governance systems was a key feature of my research problem. Therefore, achieving my aim of better understanding the commodification of waste – including ideas with political traction – which is shaping and shaped by institutionalised urban waste governance was bound to be a challenge, demanding a research design which opened itself to various dimensions of explanatory substance.

6 Conclusion

This short chapter summarises my overall findings and research outputs to conclude the thesis. I reflect on the achievement of my research aim, objectives, and questions. I integrate the respective reflections with brief explanations of the significance and implications of overall findings for policy and practice, and with brief summaries of my novel contribution to knowledge vis-à-vis key sources. I pose certain challenges which future research may overcome and offer directions.

My aim in this research was to better understand the commodification of waste – including ideas with political traction – which is shaping and shaped by institutionalised urban waste governance. This gave rise to three objectives linked to three research questions. My research questions were:

1. What is the composition and structure of urban waste governance systems wherein the circular economy and food-energy-water nexus concepts have become institutionalised?

2. How does ideational power relate to emancipatory institutional change in contemporary urban waste governance; and what does this mean for social-environmental challenges?

3. What factors influence the process of institutional change in urban waste governance systems; and what compositional or structural outcomes emerge over time as a result?

I briefly reflect on each of these research questions and corollary objectives respectively below.

6.1 Fostering constructive chaos

I first set out to identify and critically analyse institutions sharing explicit alignment with circular economy or food-energy-water nexus ideas, as well as the relationships between these institutions.

My critical reading of CE and FEW nexus literature foregrounds two attributes: interdependence and heterogeneity. These contrasting attributes present a tension of difference and togetherness. Thinking in such colloquial terms makes the mind wander in a sociological direction: a direction which I find lacking in CE and FEW nexus literature. I proceeded to start where Allouche et al. (2019) left off, emphasising allegedly neglected asymmetries of power characterising interrelated social structures that are galvanised by powerful ideas which *seem* socially innocuous, such as the FEW nexus. Whilst leading me to environmental governance theory as well as critical institutionalism theory, CE and FEW nexus literature alludes to a tacit but significant trend. That is, whilst the discursive popularisation and theoretical endowment of these ideas seems to be advancing, especially in economically influential nations or cities, underlying institutional orders such advancement surely depends on and reinforces seem to be somewhat under-investigated.

I therefore set out to construct a methodological design which could illuminate the underlying institutional orders in question. Whilst conceptualising this design, the overarching themes of interdependence and heterogeneity I find in CE and FEW nexus literature align with tenets of environmental governance theory, the first pillar of my theoretical framework. Therefrom, and specifically from the more generic theoretical precedents of Rhodes (1996) and Kooiman (1999), the phenomenal relevance of networks presents itself. Contemporary works of environmental governance theory resonate with what I think of as a tension between difference and togetherness: the role of semantic phenomena in the institutionalisation of environmental governance *networks* (Cowell et al., 2020; Koch et al., 2021). This literature had a major influence on how I used SNA.

In answer to my first research question and my first research objective, my findings are as follows.

I find conceptual confluence between trends in environmental governance theory and the structural-compositional nature of studied urban waste governance networks. I also find the emergence of commodified "*knowledge production*" problematic in different cities – especially since the phenomenon of governance *integration* is widely supported by literature (Partelow et al., 2020). The production of knowledge – and therefore the production of power if we follow the ideational notion of power – is not a socially innocuous activity. Both the network-like property characterising contemporary urban waste governance systems as well as their asymmetries of power (which is a rather widespread target of critique in current institutionalism literature) emerge from my SNA findings, alongside the primacy of discourses. There are, crucially, detailed nuances to the structural and compositional nature of government-business relations which tend to dominate the asymmetries of power so widely critiqued in the literature. It would be most instructive for further research to unravel and challenge these important nuances.

I highlight three distinctive and novel contributions which, I argue, my findings may offer such endeavours. First, the approach I took to discourse in the application of my SNA focused neither on individuals nor on formal statements. Instead, I took an unconventional approach to what discourse can be in this digital age where **dematerialised commodities are becoming supremely valuable**; which is partly due to the proliferation of information and communications technologies (Barabasi & Albert, 1999; Borgatti et al., 2009). This approach yields convincing representations of networked institutional relations comprising urban waste governance systems.

Second, I find instantiations of new forms of asymmetry wherein dominance is best understood as a negotiated or shared phenomenon – thus demonstrating how traditional policies of categorical or institution-specific accountability appear to be falling behind the reality of fast-paced, ever-present processes of institutional change. It is not enough for critical thinkers to trace hierarchies of ideational power and attempt to assign responsibility accordingly as, for example, Carstensen

& Schmidt (2016) have done. I critique urban waste governance systems as instantiations of an institutionalised social order of capitalism and agree with Boltanski & Fraser (2021) in this respect. I therefore argue that scholars should take care not to become embroiled in the production of knowledge (albeit critical) without maintaining a high level of reflexivity and mindfulness of how it may affect policy / practice. This is pivotal because **critique may indeed be increasingly vulnerable to commodification in competitive environments of institutional change**.

Third, combining environmental governance theory and critical institutionalism theory in my design and implementation of SNA amplifies the imperative of critique by revealing the trend of business-government dominance across various cities. Critique can transcend the logic of commodification that permeates urban waste governance networks which embody innovative, metamorphic forms of government-business domination. Responding to this imperative of critique is particularly challenging now because institutionalised, and thus authoritative, wellsprings of critique are not immune to the all-pervasive nature of the power in capitalist ideas. Therefore, I disagree with Beunen & Patterson (2019: p. 25) in their proposal that institutional orders in environmental governance – which I find to be variably asymmetrical with regards to the case of waste in Rotterdam, Bristol, and Cape Town – need not be "*questioned all the time*". Indeed, if we take Beunen & Patterson (2019) up on their suggestion to expand our horizons by taking the effects of unintentional forms of agentive activity on institutional change into account, passively opting not to level constant, open, and constructive forms of critique carries great risk. This is supported by the ABM finding suggesting that the structural and compositional outcomes of urban waste governance networks are strongly influenced by stabilising factors. Hence, I argue, **emancipatory institutional change may be forthcoming from constructive de-stabilisation**.

Such de-stabilisation may already emanate from academic conferences, third sector protests, and parliamentary debates, but further research on how radical forms of contestation can be brought to bear on the regulatory, semantic, and material modalities of government-businesses dominated urban waste governance systems would be instructive. My findings therefore suggest that serious consideration should be given to how existing structures can be dismantled or at least destabilised, and to how dominant institutions can be eliminated or weakened, to foster "constructive chaos".

6.2 Distilling diluted domination

The previous argument, which can be encapsulated in the phrase "constructive chaos", converges with the answer to my second research question and with the fulfilment of my second research objective: to investigate and critically analyse the role of ideational power in processes of institutionalisation, or institutional change, within urban waste governance systems. Having identified the key attributes of the urban waste governance systems in question as network-like

and asymmetrical – embodying the themes of interdependence and heterogeneity I took away from my reading of the CE and FEW nexus literature – some final reflections follow below.

My findings do not support a theoretically universal conclusion that the power in CE and FEW nexus ideas, *per se*, restricts solutions to the urban waste problem solely to commodification. My findings do support, rather, a contextual conclusion. The power in these ideas does affect urban waste governance networks and interacts with their potential for emancipatory institutional change, but such effects and interactions are contingent on distinct spatiotemporal conditions. This context-specificity poses a challenge in understanding, in general terms, what my findings imply for waste governance practice and policy. This challenge is compounded by my findings which expose the problem of dematerialised commodification in urban waste governance, since a growing proportion of "practice" is overtly geared to influence "policy". But a generalisation of my findings is also challenging because the way in which different shades of critique (understood as a distinct and crucial practice which may affect the trajectory of institutional change in urban waste governance systems) interact with social reality in different places is so specific that the implications for policy and theory must be inferred carefully. There are cross-cutting issues which any place-specific policy ought to address. In this regard, a key example is my finding that, across all contexts, the nexus of financial and political control plays an important role in shaping the interplay between power in CE and/or FEW nexus ideas and potential emancipatory institutional change. The extent to and way in which these ideas are institutionalised, and the degree to which critique features in each waste governance network, differs across the three case study cities.

I address the latter difference in more detail below, but the former difference (in how CE and/or FEW nexus ideas were institutionalised in each city) is evident from the divergent structural attributes I appraised using my SNA. This relates to the specific quasi-reified definition of "institutions" which I employed in this research: encompassing regulatory, semantic, and material dimensions of meaning (Boltanski, 2011). The application of my mixed methodological design highlights the semantic dimension. But importantly, I find that the boundaries between said dimensions are becoming increasingly blurred (albeit contingent on spatiotemporal conditions).

A widespread dominance of government-business relations in urban waste governance networks is crystallising in the establishment of institutional hybridisations which seek to sustain a shallow and collaborative process of institutional change. The depth of that process, whilst I generalise it as relatively shallow, is contextual. My findings indicate that where the aforementioned marriage of "civic" and "market" logics (Boltanski & Thevenot, 2006), or the purity of domination which business-government relations enjoy, is diluted by strong relations with academic and third sector

institutions, the process is shallowest. Conversely, where such domination is pure, or undiluted by links with moderately critical institutions, processes of institutional change are less shallow.

Proximate and amiable involvement of academic and/or third sector institutions in urban waste governance networks is not necessarily conducive to fundamental (emancipatory) institutional change. Rather, my findings point to hybridised institutionalisations of waste as a commodity – transcending the material realm of waste recycling or industrial reuse – related to competitive "*discursive coalitions*" manifesting in regional government-businesses relations (Carstensen & Schmidt (2016: p. 331) paraphrasing Howarth (2009)). This might explain the tense co-existence of politicising and de-politicising elements in shallow processes of institutional change which fail to alter the fundamental institutional orders which such "*rhetorical splicing*" of "civic" and "market" logics can use to justify domination (Flynn & Hacking, 2019; Cowell et al., 2020, p. 4).

I find an important dissonance between the relative degrees to and manners in which critique has become mainstream, and related potentials for emancipatory institutional change in urban waste governance systems. Critique featured across the respective cities whose waste governance networks I investigated, but neither in the same way nor with the same force. Whilst embracing Cowell et al.'s (2020: p. 9) finding that "*turbulence is becoming the new normal*" in UK-EU waste governance, this study went further by assessing city-specific critiques against the backdrop of a global context of interdependent crises. I associate this interrelated, global environmental-economic-political crisis with our all-pervasive and metamorphic institutionalised social order: capitalism (Diamond, 2015; Piketty, 2015; Boltanski & Fraser, 2021; Wunderling et al., 2022).

I posed the question as to whether there is sufficient ideational dissent in the governance networks which I identified and analysed to bring about emancipatory institutional change that addresses that general crisis. I find contextual variance in terms of the manner in and degree to which critique, or ideational dissent, has become a "mainstream" activity in urban waste governance processes – *without* correlating divergence in low levels of potential for emancipatory institutional change. In my assessment, Bristol's waste governance network is an outlier insofar as the diverse institutional representativeness of critical voices is concerned. This resonates with the structural and compositional distinctiveness of the waste governance network in Bristol, comprising a relatively compact and tightly knit web of third sector, business, and government institutions with individual members who seem to play multiple and fluid roles across institution-type and nexus-type categories. Yet, the structural and compositional resonance with critique dissolves when the waste governance networks of Cape Town and Rotterdam come into focus.

Unlike Rotterdam, in Cape Town neither the CE nor FEW nexus ideas are institutionalised in a well-integrated network that can be neatly traced online. Rather, the purity of domination in both

Cape Town and Rotterdam is the distinguishing factor which separated them from Bristol in terms of the extent to which critique has become mainstream in their waste governance networks.

An important part of the contribution this thesis makes is my incorporation of substantive and impactful elements of political contestation: something that cannot be ignored in a critical analysis of ideational power in urban waste governance which is sensitive to context (Fraser & Jaeggi, 2018). Relating the relative purity of domination in the respective urban waste governance networks I appraised in this research to their divergent contexts of political contestation assists my explanation and understanding. But a crucial point in my overall conclusion is owed to my application of critical institutionalism theory, as well as some selected critical sociological works, to waste governance networks in cities operating in a global societal context of capitalism.

That crucial point is this: the difference between how and to what extent critique has become a mainstream feature of these comparative networks does not mesh with relative potentials for emancipatory institutional change. I contend that this finding amplifies Boltanski & Fraser's (2021) argument which states that critique has become a blunt instrument in capitalist societies. But more specifically, taking my qualitative and ABM findings together, I theorise that **effective critique capable of neutralising and/or eliminating dominant institutions in urban waste governance is lacking**. My interpretation of the extent to which critique is ingrained in waste governance networks thus becomes negative: *i.e.*, more ingrained critique is not necessarily conducive to radical change. I thus argue that deeper *incorporation* of critique is probable to result in shallow processes of institutional change which fail to produce emancipatory outcomes. One solution to this problematic failure is intensive critical work to distil diluted domination. That is, rather than welcoming the incorporation of critique in (albeit variably) asymmetrical systems of waste governance in our cities, **analytically separate different components of muddied waters in order to effectively scrutinise the discrete components of aggregate dominance**.

6.3 Inviting the unorthodox

The proposed solution of "distilling" diluted forms of domination in urban waste governance is related to my answer to the third research question. It thus also relates to the fulfilment of the third and final research objective: to synthesise and simulate factors affecting the outcomes of institutionalisation or institutional change aligned with circular economy or food-energy-water nexus discourse in different urban waste governance systems.

Rather than fuelling a cacophony of ineffectual "*critique for the sake of critique*", I aimed to offer a deep and reflexive critique of urban waste governance institutions (Boltanski & Fraser, 2021, p. 16). The original approach I took for this critique hinged in large part on my starting research design which enabled me to understand urban waste governance as part of a larger, wider problem.

Discursive consolidation around the commodification of waste – as the antithesis that motivated my research design and problem – has been critiqued. My approach and findings make a distinct contribution by diverging from similar examples of scholarship. In the paragraphs below, I highlight a few of these main contributions and divergences from current theoretical positions.

My research design assumed that highly interconnected or harmonised institutional arrangements are probably undesirable in the context of ideational power, an assumption which diverges sharply from affirmative starting assumptions used, for example, by Koch et al. (2021) in their analysis of narrative congruence and its constitutive function for linked environmental governance entities. Again, using Koch et al. (2021) for contrast, my findings diverge from the positivist position which assigns credibility to the content and import of subjective statements of individual intent. Therefore, I opted to take a step further by combining social network analysis and qualitative analysis with agent based modelling: a stochastic analytical method that embraces indeterminacy. This approach is partly informed by Beunen & Patterson's (2019) instructive proposal for the fusion of environmental governance theory with the cornucopia of institutionalism theory on offer – and their especially strong emphasis on the potential salience of *unintentional* institutional work. In answer to calls emanating from both environmental governance and critical institutionalism scholarship, I investigated multiple, dynamic empirical contexts with enough consistency to compare them; something which related works have not done, but indeed warrant (Carstensen & Schmidt, 2016; Beunen & Patterson, 2019; Lok, 2019; Duygan et al., 2021; Koch et al., 2021).

As a result, I now foreground the second pillar of my theoretical framework which has in large part operated in the background of this study and my presentation of findings. Besides taking up Beunen & Patterson (2019) on their important recommendation to tap into potential synergies between environmental governance theory and institutional scholarship, I applied critical institutionalism theory with due regard for some of the most important shortcomings in this realm. Lok (2019) served as an especially pivotal point of departure in my application. Most significant, I suspect, is the strong influence my reading of critical institutionalism had on my selection and use of a systems thinking analytical framework and a "context in the interaction between research and government policy" conceptual framework. As Lok (2019: p. 344) implored, I attempted to establish a partly "*problem-driven, instead of purely theory-driven*" research design whereby I emphasised not only **the process of institutional change, but also the consequent potential for emancipatory outcomes** in the tangible context of urban waste governance as a small solution to environmental degradation, economic inequality, and democratic recession in a capitalist society.

Findings emanating from this approach are valuable because they are made in direct relation to existing policies defining the regulatory landscape within which waste governance practices can

be contested with the ideational power *of* CE and FEW nexus ideas. Yet, alongside a divergence from positivism – responding to Lok (2019) – I employed a modest research design by analysing my data through a systems thinking lens allowing epistemological reflexivity. By anchoring my study mainly in an aspiration to address significant problems facing society, I attempted to prevent this research from reinforcing the power in ideas which restrict imaginaries of alterity. Likewise, I have acknowledged the limitedness of *borrowing* ideas and concepts from adjacent bodies of literature, as I did from critical sociology and other institutionalisms, to ensure that my use of such ideas and concepts is not misunderstood as an exhaustive representation of their value. As my contribution shows, the simple act of imbuing certain ideas with authority has implications. This is akin to the dematerialised trend of commodification in urban waste governance networks where domination is relatively diluted. Such dilution, I argue, partly explains why fundamental or emancipatory institutional change remains wanting – despite that dilution itself comprising critical voices of, for example, academia and the third sector. Rather than assuming that radical forms of critique act as "*Trojan horses*" which gain authority by aligning with institutionalised ideational power in asymmetrical urban waste governance systems and effecting emancipatory incremental change through a "*pragmatist ethics*" (Nunes, 2017), **moderately or superficially critical agents could embolden purer forms of domination by diluting them** (Lok, 2019, p. 346). But there are also temporal and contextual factors such as the maturity of CE and FEW nexus discourses – especially with regards to the level and effect of critique conveyed in those. This may also be subject to unique or place-specific intergovernmental relations where some local or city governments are more aligned with national dispensations than others, thus resulting in a divergence of monetary, political, and regulatory momentum afforded to critical representatives. Of course, these dynamics operate within the broader reality of a global capitalist social system.

Returning to the blurred line between "policy" and "practice", the kinds of "institutional work" I elucidate in this research are suggestive of changes in waste governance regulations – at the very least insofar as its ideation and contestation are concerned (Lawrence & Suddaby, 2006). Beyond and in addition to Duygan et al. (2021), my findings point to the understudied relevance of social networks and discourses that constitute the fabric of dominated governance systems dealing with the cross-cutting issue of waste in cities. Continued neglect of these important underpinnings of this issue would allow our environments, livelihoods, and politics to deteriorate. The antithetical driving force of my research design means that I have had limited scope to propose alternative ways of leveraging social networks and discourses which affirm and spark imaginaries of alterity, but I call on environmental governance and critical institutional scholars to take up the challenge.

At the very least, this study has exposed otherwise opaque obstructions hindering emancipatory institutional change. I contend that this is a good place from which to start further research. I recommend future research undertaking deep, effective, and constructive critique; not only as an intellectual enterprise, but as a socially consequential practice enhancing urban environmental governance, including new forms of interdisciplinarity, trans-disciplinarity, and methodological pluralism combining computational tools and empirical approaches to solve problems in nuanced, innovative ways. That can be socially transformative waste governance: inviting the unorthodox.

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Appendix A: agent based modelling code

```
globals
[
  food-handled
  water-handled
  energy-handled
  other-handled
  nexus-colors
]

turtles-own
[
  nexus                   ;; category of nexus : 0 = food; 1 = water; 2 =
energy; 4 = other
  institution             ;; category of institution : 0 = gov; 1 = private
sector; 2 = NGO; 3 = academic; 4 = financial
  capacity                ;; waste units that can be processed
]

;;;;;;;;;;;;;;;;;;;;;;;;
;;; Setup Procedures ;;;
;;;;;;;;;;;;;;;;;;;;;;;;

to setup
  clear-all
  if save-file?
  [
    if ( file-exists? filename = FALSE )
    [
      file-open filename
      file-print "food-waste,water-waste,energy-waste,other-waste,%-
government,%-business,%-ngo,%-academic,%-financial,||,attachment-
affinity,attachment-idolization,capacity-link-influence,attachment-
expansion,attachment-stability,disruptor-probability,elimination-
probability,elimination-exponent,nexus-capacity?,||,total-agents,isolated-
agents,connected-agents,food-agents,water-agents,energy-agents,other-
agents,food-handled,water-handled,energy-handled,other-handled,avg-
degree,max-
degree,||,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25
,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,5
1,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,
77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100"
      file-close
    ]
  ]
  set-default-shape turtles "circle"
  set nexus-colors [ green blue red yellow ]  ;; food=green water=blue
energy=red other=yellow
  ;; make the initial network of two turtles and an edge
  make-node random 4 nobody          ;; first node, unattached
  make-node random 4 turtle 0        ;; second node, attached to first node
  update-capacity
  process-waste
  reset-ticks
```

```
end

;;;;;;;;;;;;;;;;;;;;;
;;; Main Procedures ;;;
;;;;;;;;;;;;;;;;;;;;;

to go
  ;; add new node
  add-node

  ;; adjust links
  add-links
  remove-links

  ;; update nodes' capacities
  update-capacity

  ;; check total waste handling
  process-waste

  ;; update ticks
  tick

  ;;check for stop condition
  if ( pause-on-full-capacity? )
  [
    if ( ( food-handled >= food-waste )
         and ( water-handled >= water-waste )
         and ( energy-handled >= energy-waste )
         and ( other-handled >= other-waste ) )
      [
      if save-file? [ save-results ]
        set pause-on-full-capacity? false
        stop
      ]
  ]
  if (ticks > duration)
  [
    if save-file? [ save-results ]
    stop
  ]

  ;; eliminate nodes, if necessary
  if ( random 100 < elimination-probability )
  [
    if ( food-handled >= food-waste )  [ remove-node 0 ]
    if ( water-handled >= water-waste )  [ remove-node 1 ]
    if ( energy-handled >= energy-waste )  [ remove-node 2 ]
    if ( other-handled >= other-waste )  [ remove-node 3 ]
  ]

  ;; update display
  layout
end


;; used for creating a new node
```

```
to make-node [ nexus-type old-node ]
  create-turtles 1
  [
    set nexus nexus-type
    set institution find-institution-type
    set color ( item nexus nexus-colors )
    set capacity 1
    if old-node != nobody
    [ create-link-with old-node [ set color grey ]
      ;; position the new node near its partner
      move-to old-node
      fd 8
    ]
  ]
end


to add-node
  ;; find the nexus-type
  let nexus-type find-nexus-type

  ;; check if is waste-handling exceeds waste produced
  let go-ahead? false
  if ( nexus-type = 0 ) and ( food-handled < food-waste) [ set go-ahead? true
]
  if ( nexus-type = 1 ) and ( water-handled < water-waste) [ set go-ahead?
true ]
  if ( nexus-type = 2 ) and ( energy-handled < energy-waste) [ set go-ahead?
true ]
  if ( nexus-type = 3 ) and ( other-handled < other-waste) [ set go-ahead?
true ]

  ;; or check if a disruptor is allowed
  if ( random 100 < disruptor-probability)  [ set go-ahead? true ]

  if ( go-ahead? )
  [
    ;; find affinity
    ;; first assume affinity is same
    let affinity-type nexus-type
    ;; then check if preference for other
    if ( random 100 >= attachment-affinity)
    [
      while [ affinity-type = nexus-type ] [ set affinity-type random 4 ]
    ]

    ;; ensure affinity-partner exists
    while [ count ( turtles with [ nexus = affinity-type ] ) = 0 ]
    [
      set affinity-type random 4
    ]

    ;; find affinity partner
    let total-affinity-links ( sum [ ( count link-neighbors ) ^ attachment-
idolization ] of turtles with [ nexus = affinity-type ] )
    let pick random total-affinity-links
    let winner nobody
```

```
    ask turtles with [ nexus = affinity-type ]
    [
      if ( winner = nobody )
      [
        ifelse ( ( count link-neighbors ) ^ attachment-idolization  > pick )
        [ set winner self ]
        [ set pick pick - ( count link-neighbors ) ^ attachment-idolization ]
      ]
    ]
    ;; make node with link
    make-node nexus-type winner
  ]
end


to-report find-nexus-type
  ;; Assigns nexus-type randomly, according to uniform probability
distribution (i.e. all are nexus-types equally likely)
  let tempnexus random 4
  report tempnexus
end

to-report find-institution-type
  ;; Assigns institution-type randomly, according user-defined probability
distribution.
  let r random 100
  let tempinstitution 0
  if ( r >= %-government ) [ set tempinstitution 1 ]
  if ( r >= %-government + %-business ) [ set tempinstitution 2 ]
  if ( r >= %-government + %-business + %-ngo ) [ set tempinstitution 3 ]
  if ( r >= %-government + %-business + %-ngo + %-academic ) [ set
tempinstitution 4 ]
  report tempinstitution
end


to add-links
;; creates additiopnal links between agents, according to probability
(attachment-expansion)
;;      accounts for attachment-affinity
;;      currently not accounting for attachment-idolization
;;      currently not checking if link already exists
  if (random 100 < attachment-expansion)
  [
    let pick one-of turtles
    ask pick
    [
      let nexus-type nexus
      ;; find affinity for new link-partner
      ;; first assume affinity is same
      let affinity-type nexus-type
      ;; then check if preference for other
      if ( random 100 >= attachment-affinity)
      [
        while [ affinity-type = nexus-type ] [ set affinity-type random 4 ]
      ]
```

```
      ;; ensure affinity-partner exists
      while [ count ( other turtles with [ nexus = affinity-type ] ) = 0 ]
      [
        set affinity-type random 4
      ]

      ;; find affinity partner
      let partner one-of other turtles with [ nexus = affinity-type ]

      ;; create link with partner
      create-link-with partner
    ]
  ]
end


to remove-links
;; randomly removes a link between agents, according to probability (i.e. 1 -
attachment-stability)
  if ( random 100 >= attachment-stability )
  [
    let pick one-of links
    if pick != NOBODY  [ ask pick [ die ] ]
  ]
end


to remove-node [ nexus-type ]
  ;; find total probability
  let total-prob 0
  ask turtles with [ nexus = nexus-type ]
  [
    set total-prob ( total-prob + ( 1 / capacity ) ^ elimination-exponent )
  ]

  ;; pick a random number less than total probability
  let pick random-float total-prob

  ;; find the corresponding node
  let winner nobody
  ask turtles with [ nexus = nexus-type ]
  [
    if ( winner = nobody )
    [
      ifelse ( ( ( 1 / capacity ) ^ elimination-exponent ) > pick )
      [ set winner self ]
      [ set pick pick - ( 1 / capacity ) ^ elimination-exponent ]
    ]
  ]

  ;; delete the node
  ask winner [ die ]
end


to update-capacity
  ask turtles
```

```
  [
    let n nexus
    let i institution
    ;; for each turtle, its capacity is equal to 1 (self), plus any links to
agents of same nexus-type but different institution-type,
    ;; plus (optionally) any links to agents of same institution-type but
different nexus-type
    set capacity 1 + count link-neighbors with [ (nexus = n) and (institution
!= i ) ]
    if ( nexus-capacity? )
    [
      set capacity ( capacity + count link-neighbors with [ (nexus != n) and
(institution = i ) ] )
    ]
    ;; modify capacity by capacity-link-influence
    ;;   capacity-link-influence = 0.0 reduces capacity to 1;
    ;;   capacity-link-influence = 1.0 leaves capacity unchanged, i.e. well-
connected agents have higher capacity;
    ;;   capacity-link-influence = 2.0 or greater makes well-connected agents
even more productive ;
    set capacity ( capacity ^ capacity-link-influence )
  ]
end

to process-waste
  set food-handled 0
  set water-handled 0
  set energy-handled 0
  set other-handled 0
  ask turtles with [ nexus = 0 ]   [ set food-handled ( food-handled +
capacity ) ]
  ask turtles with [ nexus = 1 ]   [ set water-handled ( water-handled +
capacity ) ]
  ask turtles with [ nexus = 2 ]   [ set energy-handled ( energy-handled +
capacity ) ]
  ask turtles with [ nexus = 3 ]   [ set other-handled ( other-handled +
capacity ) ]
end
;;;;;;;;;;;;;
;;; Layout ;;;
;;;;;;;;;;;;;

;; resize-nodes, size based on degree
to resize-nodes
    ask turtles
    [
    set size sqrt count link-neighbors
    if ( ( count link-neighbors = 0 ) and ( show-isolated? ) )  [ set size 1
]
    ]
end

;; display network
to layout
  ;; the number 3 here is arbitrary; more repetitions slows down the
  ;; model, but too few gives poor layouts
  repeat 3 [
```

```
    ;; the more turtles we have to fit into the same amount of space,
    ;; the smaller the inputs to layout-spring we'll need to use
    let factor sqrt count ( turtles with [ count link-neighbors > 0 ] )
    if factor = 0  [set factor 1] ;; this should never happen, but it does
anyway...
    ;; numbers here are arbitrarily chosen for pleasing appearance
    layout-spring ( turtles with [ count link-neighbors > 0 ] ) links (1 /
factor) (7 / factor) (1 / factor)
    display  ;; for smooth animation
  ]
  ;; don't bump the edges of the world
  let x-offset max [xcor] of turtles + min [xcor] of turtles
  let y-offset max [ycor] of turtles + min [ycor] of turtles
  ;; big jumps look funny, so only adjust a little each time
  set x-offset limit-magnitude x-offset 0.1
  set y-offset limit-magnitude y-offset 0.1
  ask turtles [ setxy (xcor - x-offset / 2) (ycor - y-offset / 2) ]
end

to-report limit-magnitude [number limit]
  if number > limit [ report limit ]
  if number < (- limit) [ report (- limit) ]
  report number
end

;;;;;;;;;;;;;;
;;; Output ;;;
;;;;;;;;;;;;;;

;; write to file
to save-results
  ;; open file
  file-open filename

  let outstring ""

  ;; write initial conditions
  set outstring ( word outstring ( word food-waste ) "," )
  set outstring ( word outstring ( word water-waste ) "," )
  set outstring ( word outstring ( word energy-waste ) "," )
  set outstring ( word outstring ( word other-waste ) "," )
  set outstring ( word outstring ( word %-government ) "," )
  set outstring ( word outstring ( word %-business ) "," )
  set outstring ( word outstring ( word %-ngo ) "," )
  set outstring ( word outstring ( word %-academic ) "," )
  set outstring ( word outstring ( word %-financial ) ",||," )

  ;; write control parameters
  set outstring ( word outstring ( word attachment-affinity ) "," )
  set outstring ( word outstring ( word attachment-idolization ) "," )
  set outstring ( word outstring ( word capacity-link-influence    ) "," )
  set outstring ( word outstring ( word attachment-expansion       ) "," )
  set outstring ( word outstring ( word attachment-stability       ) "," )
  set outstring ( word outstring ( word disruptor-probability      ) "," )
  set outstring ( word outstring ( word elimination-probability    ) "," )
  set outstring ( word outstring ( word elimination-exponent       ) "," )
  set outstring ( word outstring ( word nexus-capacity? ) ",||," )
```

```
  ;; write main results
  set outstring ( word outstring ( word count turtles ) "," )
;; total-agents
  set outstring ( word outstring ( word count turtles with [ count link-
neighbors = 0 ]  ) "," )     ;; isolated-agents
  set outstring ( word outstring ( word count turtles with [ count link-
neighbors > 0 ]  ) "," )     ;; connected-agents
  set outstring ( word outstring ( word count turtles with [ nexus = 0 ]   )
"," )                    ;; food-agents
  set outstring ( word outstring ( word count turtles with [ nexus = 1 ]  )
"," )                     ;; water-agents
  set outstring ( word outstring ( word count turtles with [ nexus = 2 ]   )
"," )                    ;; energy-agents
  set outstring ( word outstring ( word count turtles with [ nexus = 3 ]  )
"," )                     ;; other-agents
  set outstring ( word outstring ( word food-handled  ) "," )
  set outstring ( word outstring ( word water-handled       ) "," )
  set outstring ( word outstring ( word energy-handled      ) "," )
  set outstring ( word outstring ( word other-handled       ) "," )
  set outstring ( word outstring ( word mean [count link-neighbors] of
turtles ) "," )
  let max-degree max [count link-neighbors] of turtles
  set outstring ( word outstring ( word max-degree ) ",||," )


  ;; write degrees
  let degree 0
  while [ degree <= max-degree ]
  [
    set outstring ( word outstring ( word (count turtles with [ count link-
neighbors = degree ] ) ) "," )
    set degree ( degree + 1 )
  ]
  file-print outstring

  ;; close file
  file-close
end

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```