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Disposing of Single-Use: Sustainability Transitions Towards Waste-Free Systems

By

Jessica Heiges

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Environmental Science, Policy, and Management

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Kate O'Neill, Chair

Professor Alastair Iles

Professor Kris Madsen

Spring 2023

Abstract

Disposing of Single-Use: Sustainability Transitions Towards Waste-Free Systems

by

Jessica Heiges

Doctor of Philosophy in Environmental Science, Policy, and Management

University of California, Berkeley

Professor Kate O'Neill, Chair

Waste is being generated and discarded at unprecedented and alarming rates. Waste of all materials and products is creating air, water, and soil pollution, causing biodiversity loss and harming human health. Such destruction came fast and such destructive practices can be altered. That alteration, I propose, can come through a policy-based sustainability transition towards waste-free systems.

I introduce the term 'towards waste-free systems' as, I hope, a unifying and galvanizing term to align an otherwise disparate preexisting assemblage of actors fostering or inhibiting action towards less waste. In support of wastelessness, many actors have made substantial and remarkable inroads against the locked-in make-take-discard consumption culture. They have passed policies, created alternative use systems, and conducted cross-disciplinary education and awareness. They have removed persistent organic pollutants from our packaging, increased producer responsibility in the disposal process, and curbed the use of some of the most damaging materials. Yet, waste continues to be generated, ecosystem harm continues, and human health continues to be compromised.

In this dissertation, I propose we can make substantially more progress by framing and driving a sustainability transition towards waste-free systems through policy strategies. Co-authors and I conducted numerous studies, at varying geographical scales, through multiple methodologies, to examine policies as they relate to the sustainability transition towards waste-free systems. These studies include a review of all anti-single use disposable (SUD) foodware policies in the US; an assessment of the effectiveness of one historic anti-SUD foodware policy in Berkeley, California; an impact-based approach of China's policy to no longer accept 70% of the US's discarded plastics; and a deep dive into the policies paused, by whom, and for what reasons, that spurred the creation of exorbitant SUD foodware and healthcare waste ('hygiene waste') during COVID-19.

These studies, grounded in sustainability transition theory and discard studies, demonstrate that achieving waste-free systems is both obtainable and necessary, but that such efforts face many obstacles along the way.

For those who feel that a single action can make a positive change, whether that action be on a podium, in a picket line, or with a pen.

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List of Acronyms and Abbreviations

BPI	Biodegradable Products Institute
BYO	Bring Your Own
CalRecycle	California Department of Resources Recycling and Recovery
CDC	Centers for Disease Control and Prevention
CO ₂ e	Carbon Dioxide Equivalent
DAP	Dynamic Adaptive Planning
DIR	California Department of Industrial Relations
DMC	Disaster Management Cycle
DMDU	Decision-Making under Deep Uncertainty
DRIFT	Disaster Resilience Integrated Framework for Transformation
DRR	Disaster Risk Reduction
EBT	Electronic Benefits Transfer
EPR	Extended Producer Responsibility
ESP	Expanded Polystyrene
FEWS	Food-Energy-Water System
GAIA	Global Alliance for Incinerator Alternatives
HiAP	Health in All Policies
LEA	Local Enforcement Agency
MRF	Materials Recovery Facility
MLP	Multi-Level Perspective
MSW	Municipal Solid Waste
Mt	Metric Tons
NASHP	National Academy for State Health Policy
NGO	Non-Governmental Organization
NPI	Non-Pharmaceutical Intervention
OSHA	United States Occupational Safety and Health Administration
PAHO	Pan American Health Organization
PET	Polyethylene Terephthalate
PIA	Plastics Industry Association
PPE	Personal Protective Equipment
R&D	Research and Development
SB	Senate Bill
STP	Sustainability Transition Policy
SUD	Single Use Disposable
SUF	Single Use Foodware
U.S. EPA	United States Environmental Protection Agency
UN	United Nations
UNEA	United Nations Environment Assembly
WHO	World Health Organization
WIC	Women, Infants, and Children
WTO	World Trade Organization

Preface

Before getting into my dissertation, I wanted to provide some background on how I got here. Not unlike my studies, I am amidst a non-linear transition. In this case, it is a personal transition to pursue a career in my purpose: waste-free systems.

I did not grow up considering what my purpose was. I diligently followed rules, fulfilled expectations, and progressed accordingly. However, this kind of life was deeply unrewarding and unnerving; I did not identify with, or particularly like, the trajectory I was on. That is because I did not take the time or create the space to better understand what brings me frustration, excitement, and equanimity, all emotions to help cultivate my purpose. I was, effectively, progressing without purpose.

The widening dissonance between self and actions prompted me to search extensively into my frustrations, excitements, and sources of equanimity. That search always came back to waste: I was frustrated by how it permeated our streets, rivers, and bodies; I was excited to learn about and implement solutions to curb waste generation; and I obtained equanimity in knowing that such solutions were viable and that positive change could happen despite myriad challenges. This realization that my purpose was grounded in waste galvanized me to change the system in which I was operating so I could better understand and pursue my purpose. And I knew I needed to go to graduate school to work toward that changed system of operation.

I began my graduate tenure in the Master of Development Practice at UC Berkeley, a degree grounded in equipping students to support and lead sustainable and equitable development. I immediately came into my own because I dove deeply into the world of waste. I took innovative courses, devoured thought-provoking articles, spoke with similarly frustrated/ excited/ equanimous classmates and professors, attended guest speaker presentations, joined clubs, and applied my burgeoning skills and newly awakened purpose to foster transitions to waste-free systems. I finally found my purpose and was in the early stages of engaging every single leverage point to better my chances at a successful transition to a life dedicated to the purpose of supporting waste-free systems.

At the end of my master's degree, I was fortunate to be accepted to UC Berkeley's Department of Environmental Science, Policy, and Management's doctoral program to further establish a grounding in, as well as contributions to, sustainability transitions to waste-free systems. I was frustrated that there was limited systems-based and transitions-focused research on waste. I was excited that there were novel policies that were completely disrupting the waste space. And I was equanimous in knowing that there were endless possibilities for reducing the amount of waste generated. This doctoral degree was the second phase of my 'purpose transition' and it felt good, it felt right.

I am now in the third phase, translating my purpose for waste-free systems into a career outside of academia. Can I successfully complete this personal transition by obtaining an impactful and rewarding career in such transitions? What are the metrics of 'success' to gauge progress? How will I know if it is 'complete' or if it has 'failed'? What strategies are 'effective'? The studying of sustainability transitions provides reflections, theories, and frameworks to potentially adapt toward this purpose-driven transition. However, I have learned that this personal pursuit toward a career fulfilling my purpose is more of an art than a science.

If it were not for my team of supporters, then I would still be meandering, not close to catalyzing or progressing the transition toward my true purpose. I am incredibly grateful to that team. I mention many of the members below, but there are so many more. It is clear that a transition cannot be done alone – nor can a doctorate – and it is clear that transitioning to pursue your purpose can be frustrating, exciting, and bring equanimity.

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Chapter 1

Introduction

1. Introduction: Sustainability Transitions to a Waste-Free System

Sustainability transition research is a field focused on identifying and thus elucidating the components that foster or impede a transition towards a more 'sustainable' state. Most analyses are *ex post* (after), while some are *ex ante* (before), and a very few are *ex nunc* (during) (Crabb & Leroy, 2012). This burgeoning field has proposed numerous frameworks that have overlapping but differing intents, benefits, and shortcomings (Köhler et al., 2019). The frameworks differ in their focus on a specific sector (e.g., electricity or transportation), or the language and tools used (e.g., multilevel perspective versus leverage points). According to preeminent scholars in sustainability transitions, the field has "developed rapidly" since 2009 (Köhler et al., 2019, p.2). That means that the frameworks are emerging versus strictly prescribed for a particular analysis, therefore to be used as a guide instead of a firm analytical structure.

In 2019, 29 preeminent sustainability transition scholars published a piece that outlined the current standing of subfields within the larger sustainability transitions field, as well as projections for the need and likely direction of sustainability transitions (Köhler et al., 2019). This paper was noteworthy because it not only gathered scholars that have, at times, been in opposition (Delina & Diesendorf, 2013; Geels & Schot, 2007; Genus & Coles, 2008; Kester & Sovacool, 2017), but it also succinctly outlined the nascent yet emerging field. In a field that focuses mostly on theorizing, but also analyzing and fostering transitions, this paper helped create a vision for the direction of the field. However, the paper, which provided eight subfields and one reflection on methodologies, was configured more around the specialties of the authors than a unified and systematic critique or categorization of the field. In this Introduction I map out today's various sustainability transition frameworks from a different perspective that stems from studying the transition towards waste-free systems, from the local to the global level. This perspective coalesces the various sustainability transitions frameworks into where, when, who, and how of a sustainability transition.

Another differentiating component of my categorization of such transitions is the emphasis on governmental and public policy. In Köhler et al. (2019), policies are subtly included in numerous subfields (e.g., power and politics of transitions, governing transitions, and ethics of transitions). A few contributing authors have devoted their research to the analysis of policies in sustainability transitions (Kivimaa & Kern, 2016), while others feel it is a component but not always necessary for such transitions (Geels & Schot, 2007). I argue that informal or formal policy at the local, regional, and global level is always a necessary component of a sustainability transition. A policy's contribution to such a transition might be fostering it or might be inhibiting it; the policy might create the intended result, or because of the policy's characteristics (breadth of policy mechanisms), intensity (comprehensiveness of a single policy), and/or technological specificity (the fostered niche-innovation), it might fail to achieve the intended results. There is an argument that transnational policies are crucial to codify a norm (Dauvergne, 2018b). I argue that transnational policies are not necessary to 'complete' a transition, but are a critical component within the sustainability transition lifecycle (Clapp & Swanston, 2009; Crabb & Leroy, 2012; Kivimaa & Kern, 2016; Rosenbloom et al., 2020). The importance of policies and the phase of the transition lifecycle within which they are presented and enforced varies substantially based on

the where, when, who, and how of the sustainability transition. Each transition context is unique, even if the transitions are occurring in neighboring jurisdictions (Slafter, 2019; Chapter 3).

One theoretical framework within sustainability transitions is Sustainability Transition Policy (STP). STP focuses on the policy’s role in a sustainability transition. It is a way to reorient policies – from development to implementation to enforcement – to make them better support a sustainability transition. According to Rosenbloom et al. (2020), STPs address systems problems that are inherently political through context-specific responses; STPs are sustainability transitions built and fostered by policy. While Rosenbloom et al. (2020) and other supporters of STP convey the importance of STP, they do not go to the length that I argue: that policy is a fundamental component of a sustainability transition. I develop this argument through studying methodologies, scales, and timeframes surrounding the sustainability transition towards waste-free systems. It is therefore through those studies – which are presented in the following four chapters – coupled with STP theory that I developed the emerging sustainability transitions dimensions centered on policy and grounded in the who, where, when, and how for sustainability transitions.

This Introductory chapter has four parts. The first part addresses the crucial underpinning and thus impetus of a sustainability transition, the ‘why’, which I posit is inherent harm that is unequally distributed. I then provide background on the terms that are the backbone for the field I study and for which I developed the concepts – ‘towards waste-free’ and ‘system’ – which can also be considered the ‘what’. In the second part, I outline the four new sustainability transitions dimensions: who, where, when, and how. In the third part I address effectiveness: a large, often missing component of the sustainability transitions field, which is increasingly important to evaluate the ‘change in progress’ as both the sustainability transitions field and STP gain traction. In this section I discuss the wide range of policies within the waste-free sustainability transition, the policy gaps, and the effectiveness or ineffectiveness of each policy type. Finally, in the fourth part, I outline the following chapters and how they leverage an analysis of a particular policy transition towards waste-free systems, and how that policy contributes to the transition.

This dissertation is grounded in four studies. However, over my PhD career, I conducted numerous other studies that have contributed to the learnings presented here. In Table 1.1 I outline all of those studies, with their title, co-authors (if applicable), description, year, and publication (if applicable) and chapter (if applicable). This table aims to be a quick guide as I refer to the different pieces throughout the Introduction and Conclusion chapters.

Title	Co-authors	Description/ brief findings/outline or purpose	Date	Associated Publication; Chapter in Dissertation
Eliminating Single Use Disposable Foodware: An Emerging and Cascading Norm	Heiges, J.	The norm emergence theory describes the lifecycle of how a norm can go from ideation to societal embeddedness. The policy mix framework provides an analytical structure to the different types of policy mechanisms. In combining the theory and the framework, I provide an analysis on the anti-SUD foodware policies and how they contribute to the anti-SUD foodware norm being in the	2023	Environmental Innovation and Societal Transitions [published]; Chapter 2

		'cascade' phase toward societal embeddedness.		
Evaluating the Effectiveness of an Anti-Single Use Disposable Foodware Policy: Reaching for Sustainability in Berkeley, CA	Bourque, M., Parra, A., Shorter, D., & O'Neill, K.	In 2019, Berkeley, California adopted the most comprehensive anti-SUD foodware policy. We conducted a longitudinal quantitative observational survey study to assess prepared food vendor compliance with the ordinance, and thus effectiveness of the policy's three mechanisms.	n.d.	Elementa [to be submitted]; Chapter 3
A Recycling Reckoning: How Operation National Sword catalyzed a transition in the U.S. recycling system	O'Neill, K.	In 2018, China, the largest importer of U.S. plastic waste and scrap, restricted the type of scrap it would import. This massively disrupted the U.S. plastics recycling system, catalyzing a 'de-alignment'. The U.S. plastics recycling system can enter the 're-alignment' transition pathway, or it could enact more methodical tactics to become a more sustainable system.	2022	Journal of Cleaner Production [published]; Chapter 4
Preventing the Influx of Waste in Future Disasters: Reflecting on COVID-19	Iles, A. & O'Neill, K.	COVID-19 is a disaster. Early in the pandemic, there were three groups of actors (governments and agencies, industries, and consumers) that made decisions based on fear and uncertainty. Those decisions resulted in SUD foodware and healthcare waste, with the intention of improving hygiene and reducing contagion. We named this novel and prolific waste stream 'hygiene waste'.	n.d.	TBD; Chapter 5
UC Berkeley Chou Hall: Can the TRUE Zero Waste team Overcome Challenges to Achieve Top Certification?	Schultz, F.	Chou Hall at the University of California, Berkeley was the first TRUE Zero Waste certified academic building in the world. It achieved this accreditation through stakeholder management, determining the role of leadership in change initiatives, and cultivating a shared mission and strong organizational structure.	2023	BerkeleyHaas Case Series
Disposable Free Berkeley	Bourque, M. & Mitchell, J.	The components and the unanimous passing of Berkeley's Single Use Foodware and Litter Reduction ordinance was unprecedented. We developed a toolkit for other anti-SUD foodware policy advocates, practitioners, and researchers to better understand the	2023	Ecology Center

		unique and generalized contexts and strategies that resulted in the historic policy.		
What analyzing National Sword can teach us about optimizing US plastics recycling	O'Neill, K.	This is a short-form article based on our research, A Recycling Reckoning. We further the discussion with a specific call to waste industry practitioners to examine and implement solutions to make the U.S. plastics recycling system more sustainable.	2022	Waste Dive
What is wishcycling? Two waste experts explain	O'Neill, K.	Wishcycling is the act of putting an item in the recycling bin while knowing that it will likely not be recycled. This hope-based act is grounded in both the desire to be more sustainable and to continue a decades-old practice. However, putting an item in the recycling bin when it should not be put there can have detrimental impacts.	2022	The Conversation
Packaging generates a lot of waste – now Maine and Oregon want manufacturers to foot the bill for getting rid of it	O'Neill, K.	There are numerous policy mechanisms that aim to reduce the amount of waste generated and discarded, however, they mostly put the waste reduction onus on consumers (e.g., recycling). Extended producer responsibility policies uniquely put the waste reduction onus on producers, thereby aiming to reduce waste 'upstream', before it even reaches the consumer.	2021	The Conversation
COVID-19 has resurrected single-use plastics – are they back to stay?	O'Neill, K.	Early in the COVID-19 pandemic, there was a proliferation of SUD items due to the pausing of current or introduced anti-SUD policies. This was caused, in part, by everyone's focus on maintaining and promoting hygiene by reducing surface-based virus transmission. However, we soon learned that the virus has an airborne transmission, yet the focus on hygiene, and thus the generation of SUD waste, continued.	2020	The Conversation
California Plastic Waste Exports: A Leverage Points Analysis	Jackson, A., Phipps, K., & O'Neill, K.	Plastic waste is a wicked problem with at least eight large, interconnected actors influencing its production and disposal. California exports large amounts of plastic waste, yet seeks to become more environmentally sustainable. That objective is obtainable through more	n.d.	N/A

		selective international recycling and by bolstering domestic recycling.		
Waste Management and Services Assessment in the Navajo Nation	Skeet, G.M., John, R., & O'Neill, K.	Few chapters (e.g., cities, counties) in the Navajo Nation have access to solid waste management and services. This results in waste mismanagement (e.g., illegal dumping and burning). We conducted a first-ever assessment of the current services as well as the opportunities and challenges to creating financially sustainable solid waste management and services across the Navajo Nation.	n.d.	N/A

Table 1.1: A repository of the manuscripts that I wrote or co-wrote during my doctorate. Each row is a separate manuscript, and includes the title, co-authors (if applicable), description, date, and where it was published (if applicable) and which chapter it is in this dissertation (if applicable).

2. Crucial Components of a Sustainability Transition

2.1. The ‘Why’: Inherent Harm

Sustainability transitions are necessary because of the inherent harm of production, use, and disposal that is unequally distributed in societal systems. The unequal distribution of harm that characterizes the waste system is demonstrated by the physical, economical, and emotional harm directly and indirectly placed on humans and more-than-human life forms (Clapp, 2002; Liboiron, 2021). If our consumption culture is to continue producing, using, and disposing in a globalized system, we need to critically evaluate and alter those inequitable dynamics and conditions. The effective alteration of those dynamics and conditions amounts to a sustainability transition (Köhler et al., 2019).

Globalization of production and consumption has, in part, necessitated sustainability transitions. The inequitable impacts of modern forms of globalization have led to many calls for sustainability transitions, including for more humane labor in textile manufacturing (Hossain, 2020; Luján-Ornelas et al., 2020), and carbon-free supply chains (Amri, 2022; Bonsu, 2020; Pyykkö et al., 2021) and economic growth (Le & Ozturk, 2020). Globalization provides economic potential through the scalability of localized resources, including labor, materials, information, networks, and other tradable commodities. The scaling of localized resources, however, has created complex supply chains, resulting in international production, use, and disposal. Waste is generated during every phase of the supply chain, from extraction to refinement, transportation to retail store, use to end use (Clapp, 2002; O'Neill, 2019). That generation is highly inequitable, negatively impacting certain geographies, communities, individuals, and habitats disproportionately (Bennett et al., 2023; Owens & Conlon, 2021; Stoett, 2022).

With a better understanding of the ‘why’, next I give context to the ‘what’: the terminology behind the studies that helped shape the four dimensions of sustainability transitions, ‘towards waste-free’ and ‘system’.

2.2. The What: ‘Towards Waste-Free’ Systems

‘Towards waste-free’ is the active progression – even if such progress includes setbacks, lateral movement, or impasses – to a system that does not generate waste. Waste is a tangible good that is not valuable; no person or entity would purchase or trade for it. Waste-free is, therefore, when by-products

generated during the manufacturing or use phase maintain value. An example of this are the textile scraps remaining after a garment is made, that are then repurposed into a garment, bag, napkin, or other good of value. Waste-free is also if there are no by-products generated during the manufacturing or use phase. An example of this is when people incorporate all edible parts of an ingredient into their meal, then compost the remaining. Waste-free is also when, after the use phase, any remaining material has value. Remaining material that has value is the cornerstone of recycling. Some goods still have consistent and high value – like metals – demonstrating the importance of recycling (however, as discussed in Chapter 4, the current recycling system must improve to better foster a waste-free system).

I have two reasons for choosing ‘towards waste-free’ as opposed to the myriad other terms that seek to capture the notion of a system without waste. The first reason is that it is a descriptive term that describes the goal of a system without waste; no additional explanation for the term is needed. It is not jargon and thus can be communicated and understood across disciplines, thereby fostering collaboration. Terms that are overly scientific or are discipline-specific can cause confusion, be ostracizing, and inhibit progress (Liboiron, 2021). This is true with three of the more prominent terms in the space: zero waste,¹ circular economy, and sustainable materials management.

The second reason is that terms in this space are continuously changing or are adopting new definitions and orientations. That includes having different actors advocating or lambasting the term. An example of this is ‘SUD’ (single use disposable), which has since evolved to ‘disposables’, then ‘single use’, and now ‘single use foodware (SUF)’. Or the many definitions of ‘zero waste’, from quantitative measures of waste reduction amounts or diversion-from-landfill rate, to qualitative measures of mimicking nature and reincorporating by-products, or a holistic adjustment to consumption patterns that rethink the commonly accepted practice of garbage generation (U.S. EPA, 2022a). For those not abreast of a term change, the first few engagements with it can be jarring and halting. Since current terms are adopting new and different definitions and uses, or the term itself is evolving, it feels disingenuous to attempt to capture an entire field of study with a morphing label. It also feels risky and irresponsible because the term, its affiliations, and its definition might continue to evolve, making this analysis almost immediately inaccurate or obsolete. The inclusion of ‘towards’ is therefore critical as it acknowledges the dynamic nature of terms, statuses, and fields of study.

One fear of mine is that there are already too many terms in this space. Adding another term, I note with irony, could perpetuate the two reasons for improved terminology, as I outlined above. While I personally advocate for the simplistic and descriptive terminology of ‘towards waste-free’, I am not so bold to presume that this will supersede other terms already firmly grounded in policy, technologies, and advocacy platforms. Instead, I hope it prompts conversation to discuss the intention(s) behind a term and evaluate if they are effective in conveying the goal and coalescing actors to obtain that goal. And I wonder if it could become an umbrella term that encompasses the above terminology.

You will also note that in subsequent chapters, co-authors and I use various terminologies, none of which is ‘towards waste-free’. The terms in those chapters were intentional because of the policy, industry, or scholarly context in which we conducted our analysis. We adopted the terminology according to the situation and audience, to better capture and communicate a phenomenon. In this Introduction I discuss the larger field, where I propose the term ‘towards waste-free’ while the other terms are meant for the specific subfields.

¹ ‘Zero waste’ can cause confusion because ‘zero’ is defined differently; in some context it means 90% diversion-from-landfill, in other contexts it means 75% diversion-from-landfill, but it never means 100% diversion-from-landfill, as the term would suggest.

Finally, a note on the next iteration of terminology: while I hope the adoption of ‘towards waste-free’ is beneficial, I know that terms will continue to evolve. My hope is that a future iteration of terminology for a system without waste includes ‘reciprocity’. Reciprocity is the act of mutual giving and taking; there is no winner or loser, none is harmed. Reciprocity is crucial for regeneration and for the health of our planet (Kimmerer, 2013). However, presently, ‘reciprocity’, like ‘regeneration’, is too contextualized, used in specific research or cultures, but not common parlance or a mental model in capital markets. That makes it unapproachable to some and unactionable to others. If terminology is meant to create a vision, elicit action, and promote collaboration (Senge, 1990), then ‘reciprocity’ is not yet ready for such a role. Further, if waste is something that is not wanted, then reciprocity epitomizes the absence of waste because one would not give to receive something that is not wanted. Reciprocity would therefore be the societal manifestation of a waste-free system.

2.3. What is ‘System’?

The term ‘system’ is proliferating, with academia, corporations, and organizations adopting the term. It is a way to communicate inherently complex, yet interconnected, processes and structures, such as ‘food system’, ‘housing system’, and ‘cyber system’. Systems theory is uniquely considered both a theoretical framework and a transdisciplinary field of study (Whitchurch & Constantine, 2009). It simultaneously captures interrelated components of a complex entity to understand behavior, then uses that relation that to explain behavior in related contexts. It breaks down open (no boundaries) and closed (with boundaries) systems to their elements (e.g., actors, institutions, policies), their relations, and the overarching purpose (Meadows, 2008). The term ‘system’ therefore describes many entities and interactions, which is both an oversimplification of the situation as well as a means to begin approaching an otherwise unapproachable situation (Wilkinson, 2011).

I posit that the overarching sustainability transition is towards waste-free ‘systems’ because it would be misleading and potentially disastrous to attempt to address only one or two components within the messy and ‘wicked problem’ that is waste generation. Furthermore, a systems framing might help people understand that solutions cannot be developed and implemented in siloes, and that collaboration plus a widening definition of ‘knowledge’ is necessary to obtain change (Kimmerer, 2013; Liboiron, 2021).

Waste disposal is complex, cross-scalar, occurs throughout supply chains, and cannot be studied or improved in isolation. Waste generation is a global systems problem and therefore necessitates global systems solutions. However, what I discuss below and in the next four chapters, is that such global system solutions do not need to be – nor should they necessarily be – global in scale. There are numerous ways to catalyze and propagate a sustainability transition and they are grounded in the pursuit of waste-free systems (what), enacting specific spatial scales (where), temporal timeframes (when), and relevant actors (who), all depending upon the nuances of the context (how). These four dimensions of sustainability transitions were derived from research on sustainability transitions to waste-free systems centered on policy.

3. Dimensions of Transition Analysis

Below I describe the four sustainability transition dimensions I propose, with evidence obtained through sustainability transitions to waste-free systems, most of which I studied during my doctoral training, and a few are demonstrated in the following chapters. The evidence from other researchers and my studies not in the dissertation are cited, while those in the following chapters are marked accordingly.

3.1. Who: Actors

The first dimension of analysis is the ‘who’, the actors. A sustainability transition is often conceptualized or propelled by a ‘norm entrepreneur’ – an individual or organization with some stable or emerging social or political capital – who promotes the niche-innovation for the greater good (Finnemore & Sikkink, 1998). In the case of transitions towards waste-free systems, this entrepreneur might be a government official (Heiges & O’Neill, 2021; Skeet et al., n.d.; Chapter 5), an activist organization (Heiges, Jackson et al., n.d.), a waste service provider (Chapter 3), a producer (Heiges, Jackson et al., n.d.; Chapters 2 and 5), an innovator (Schultz & Heiges, 2023), or a consumer (Heiges, Jackson et al., n.d.; Heiges & O’Neill, 2022b; Skeet et al., n.d.). Their role as an entrepreneur might be proactive or reactive, due to recent events or research (Shipton & Dauvergne, 2022). Further, actors have a policy preference (Lindberg et al., 2019) as well as different abilities to promote or inhibit policy (Finnemore & Sikkink, 1998), so analyzing the actors can inform who to include or not include to advance a sustainability transition.

There are also actors who do not spearhead a sustainability transition, but are key to perpetuating the transition. These stakeholders can take direct or indirect roles to implement transition changes. One way to conceptualize such stakeholders and their role in a sustainability transition is through stakeholder management. Stakeholder management is the identification of actors through relational theory as it pertains to their interest and power. The typical bucketing of stakeholders is by interest and power, forming a two-by-two grid (low to high interest by low to high power), which provides guidance on engagement. The grid’s four buckets are 1. monitor the stakeholders, 2. keep them informed, 3. keep them satisfied, and 4. manage them closely (Newcombe, 2003). In the Chou Hall Zero Waste Initiative case study, while the various stakeholders were identified before the initiative began, their interest and power were not determined, resulting in ineffective or unnecessary stakeholder-based action (e.g., requesting funding from those without decision-making power, spending too much time on those with no interest) (Schultz & Heiges, 2023). Within the Navajo Nation, through numerous focus groups, members of the initiative have not only identified various stakeholders and their interest and power with regards to improving waste management services, but have also altered their interactions with the stakeholders accordingly (Skeet et al., n.d.).

3.2. Where: Spatial Scale

Spatial scale refers to the geographical scale of where a transition occurs. As Rob Raven and Anna Wieczorek in the Köhler et al. (2019) piece describe, it is the “geography of transitions” (p.14). Placed-based transitions occur locally (e.g., village/ town, city, state), regionally (e.g., country), or at the multinational or global level. The three levels of the multilevel perspective (MLP) framework – which is a framework for sustainability transition dispersion, but not necessarily aligned with geographical scale – help elucidate the spatial scales of a sustainability transition. The MLP is a framework that models different pathways for sustainability transition. While these transitions can occur at different scales, the end result in an embeddedness of the sustainability innovation. The MLP is therefore a helpful framework to visualize scale with respect to sustainability transition dispersion.

As noted, there are three levels in the MLP, which are niche-innovation, regime, and landscape. The niche-innovation level encompasses innovations in science, economics, policy, and ideas, that capitalize on actors, relationships, power dynamics, and cultures to erode the incumbent. These niche-innovations can occur at any geographical scale, from local reuse cooperatives to the global #breakfreefromplastic movement. They are typically not coordinated efforts, unless they have reached a scale, or a tipping point. Chapter 2 describes the diffusion of the anti-single use disposable (SUD)

foodware norm, and how it has reached the tipping point toward societal embeddedness. Chapter 3 is then a deep dive into a local policy-based niche-innovation to reduce SUD foodware and foster reusable foodware, implemented in Berkeley, California in 2019.

The next MLP level, the regime, is often regionalized and considered stable as it is the set of arrangements and structures that have come to be entrenched or locked-in overtime; setting the 'rules' for how the industry or sector will work. The MLP regime is the level sustainability transitions seek to alter because it can also be known as the 'status quo' or when something is 'taken-for-granted' (Finnemore & Sikkink, 1998). Depending on the boundary of analysis, the regime can be a state/province or country. While the regime is typically what is disrupted by a catalyzed transition (the recipient), it can also be at this level that a transition is catalyzed (the disruptor). As an example, Chapter 4 demonstrates the U.S. plastics recycling system regime as the recipient of the global plastic waste trade disruption caused by China's Operation National Sword policy (Heiges & O'Neill, 2022a). As a separate example, both Maine and Oregon – states within the boundary of the U.S. – were the regionalized disruptor by catalyzing a policy-based transition through their adoption of unprecedented extended producer responsibility (EPR) legislation (Heiges & O'Neill, 2021).

Finally, the landscape level – both for geographical scale and as an MLP level – is multinational or global, such as international agreements or macroeconomics. Transitions here, while not always immediate, can arise from abrupt crises, be them socially or environmentally derived. The most recent and poignant example is that of COVID-19, which caused widespread disruption across the world. Chapter 5 provides insight into how that disruption spurred the recognition of a new waste category in the U.S. – hygiene waste – based on decisions and actions taken by three actor groups: government and agency, industry, and consumers.

3.3. When: Temporality Dynamics

Temporality dynamics frameworks focus on when a transition occurs. Sustainability transitions are non-linear, meaning (thus far) there is no discernable pattern for when a transition goes from catalyst to 'completion' (Clapp & Swanston, 2009; Dauvergne, 2018a; Finnemore & Sikkink, 1998; Shipton & Dauvergne, 2022).

The speed at which a transition occurs can be variable. Parts of the sustainability transition towards waste-free systems are vestiges of the 1970s with the advent of curbside recycling (MacBride, 2011). Curbside recycling infrastructure and services were rapidly implemented in the name of environmentalism, but no further action was taken to foster a waste-free system. In fact, as curbside recycling prevalence grew, its core sustainability attributes faded. For instance, curbside recycling began accepting problematic plastics that had no viable market for resale and routinely contaminated viable plastic resin bales, which was antithetical to recycling's original objective (Heiges, Jackson et al., n.d.). It was not until the 2010s, however, that the zero waste and circular economy movements – particularly through anti-SUD policies and practices – gained widespread acknowledgement and support to the extent that they could have (but have not) replaced the preexisting recycling system, as explained in Chapter 4 (Heiges & O'Neill, 2022a). The ongoing transition towards a waste-free system, however, was then massively derailed by COVID-19 (Chapter 5).

These timescales are different from other sustainability transitions, such as the 150-year transition to today's freshwater infrastructure in California (Gleick, 2018), or the multi-decade transition of electric vehicle adoption that is still not 'widespread' (Berkeley et al., 2017). Further, the 'stickiness' of components of the transition can influence the transition's temporality (Seto et al., 2016). For instance, since anti-SUD foodware policies were not particularly balanced (there were few of them and

they had limited policy mechanisms) or intense (they did not have clear or strong objectives to implementation) (Chapter 2: Heiges, 2023), all were more easily paused, delayed, or rolled back due to COVID-19 (Heiges & O'Neill, 2020; Chapter 5). Or, because the U.S. plastics recycling system was so reliant on China as a recipient of its waste, Operation National Sword caused immediate international instability (Chapter 4: Heiges & O'Neill, 2022a).

The perceived urgency of finding a solution in a situation can influence the norm entrepreneur composition and timescales in a transition. For instance, with the election of U.S. President Donald Trump, local government officials, activist organizations, waste service providers, and residents immediately formed a coalition to preempt policy action in anticipation of rollbacks of federal environmental regulation (Ecology Center, 2023; Chapter 2: Heiges, 2023). Reactive action (Chapter 4: Heiges & O'Neill, 2022a) plus decision-making based on incomplete information (Chapter 5) have resulted in both supportive and detrimental policy changes. This is especially true when the urgency is based on issues outside of the transition's focus, as shown when the urgency to curb a pandemic overshadowed momentum away from SUDs (Chapter 5).

3.4. How: Multilevel Perspective + Leverage Points

The final dimension of analysis is 'how': how does a sustainability transition occur? The MLP isolates the how from the when and the where, through the categorization of six transition pathways (Geels & Schot, 2007). These pathways differentiate between transitions in terms of the maturity of a niche-innovation, the number of competing niche-innovations, and the stability of the regime and landscape. The transition towards waste-free systems has multiple niche-innovations competing to gain maturity in the lacuna and disruption caused by both Operation National Sword and COVID-19. Such policy-based niche-innovations include EPR (Heiges & O'Neill, 2021), infrastructure building (Heiges, 2019; Heiges, Bourque et al., n.d.), direct regulation (Chapter 3), and changes in trade rules (Chapter 4: Heiges & O'Neill, 2022a; Heiges, Jackson et al., n.d.). While there are numerous anti-SUD foodware policies in place, they do not have sufficient balance or intensity for disaster resilience or to be considered taken-for-granted (Chapter 2: Heiges, 2023). Furthermore, other anti-SUD regulations (e.g., medical, cosmetic industry, home improvement) are nascent in comparison to anti-SUD foodware regulations, making the overall global waste-free system transition ongoing (Chapter 5).

The other prominent framework for conceptualizing how a transition occurs is via Donella Meadow's leverage points approach. Unlike the MLP's *ex post* perspective, the leverage points framework is a real-time (*ex nunc*) analysis of catalyzing or propelling a transition (Meadows, 2008).² The framework includes 12 leverage points that guide thorough examination of a system through identification and adjustments of different 'elements' (entities) and their 'interconnections' (relations), thus resulting in outsized intended impact. This might include standardizing what plastic resins are accepted by waste service providers to decrease plastic bale contamination for recycling, or developing local markets through grants, loans, or tax incentives to create greater demand for recycled material (Heiges, Jackson et al., n.d.).

4. Effectiveness of Sustainability Transition Policies

² Some of the leverage points that are most relevant to waste-free systems are parameters (e.g., taxes or subsidies), feedback loops (e.g., balancing or positive), and system structures (e.g., information flows).

For a sustainability transition to progress, it can be greatly boosted by enabling policies that are effective. One way to measure transition policy effectiveness is through assessing the policy mix used in a specific transition.

A policy mix is the framework that describes different policy types that are either ‘creative’ (foster innovation) or ‘destructive’ (erode incumbents). A policy mix for a specific sector is a “motor of creative destruction” (Kivimaa & Kern, 2016, p.206) and it is crucial to furthering a sustainability transition. In the policy mix framework developed by Kivimaa and Kern (2016), there are seven creative policy types and four destructive policy types (Table 1.2). For a transition to be effective in reaching its objective, each policy type is not needed, however, there must be representation of both creative and destructive policies (Kivimaa & Kern, 2016; Rosenbloom et al., 2020; Chapter 3).

I therefore review the representation of creative and destructive policies within the anti-SUD foodware space and analyze their effectiveness to assess the status of the anti-SUD foodware sustainability transition (Table 1.2). That is meant to provide a policy-based contextualization that I and my co-authors build throughout the following chapters. For this initial policy mix and effectiveness analysis, I define effectiveness in two ways: 1) Does the policy achieve its intended outcome of SUD foodware reduction; and 2) Does the policy further the transition towards waste-free systems? I focus specifically on the anti-SUD foodware sector because it is the most developed waste-free sector thus far, with local to national policies in many countries. This can provide a guide for other waste-free sectors to learn, adopt, and/or adapt accordingly.

Before the analysis, I want to note two points. First, there is one category in Kivimaa and Kern’s (2016) policy mix framework that was not included in the anti-SUD foodware policy analysis on effectiveness: price-performance improvements (C3). This is because, presently, there are no such policies in the anti-SUD foodware sector or there are no data on the effectiveness of those policies. I could have used proxies in related sectors (e.g., food systems); however, each sector is so nuanced in its actors, institutions, and advocates – to name a few – that a proxy would not provide sufficient insight at best and could provide misleading at worst.

Second, there are two policy categories that have components that are both effective and ineffective. These are entrepreneurial experimentation (C4) and significant changes in regime rules (D2). The reason is that each policy category has numerous policy mechanisms within it (e.g., control policies (D1) include bans, taxes, and import restrictions), some that are effective and some that are not effective. That positionality can be extrapolated to likely occur in the other categories as well; however, there are no studies that support such a claim. Table 1.2 shows the different policy categories, their definitions, and my research on if the policies are effective or not effective with regards to the anti-SUD foodware sustainability transition. The two columns on the right are what I explain in more depth in the following sections.

Policy Category	Definition	Effective	Ineffective
Creative			
Knowledge creation, development and diffusion (C1)	educational; knowledge creation; data transparency; reference/ procurement guides		education campaigns

Establishing market niches/market formation (C2)	market stimulation; economic policy instruments; public procurement	public procurement	
Price-performance improvements (C3)	subsidies for learning-by-doing; R&D support	n/a	
Entrepreneurial experimentation (C4)	diversifying offerings and capabilities; financial investments	market formation; entrepreneur experimentation; localized innovation	alternative or substituted materials
Resource mobilization (C5)	deployment of subsidies; low-interest loans; venture capital; labor-market policies; secondment of expertise	venture capital	
Support from powerful groups/legitimation (C6)	innovation platforms; public procurement; labeling		third-party certifications and labels
Influence on the direction of search (C7)	non-binding goals and voluntary actions; targeted R&D funding schemes; tax incentives	non-binding goals; voluntary actions; binding governmental goals	
Destructive			
Control policies (D1)	direct regulation; market-based; nudges; quantity limits; material requirements	direct regulation; market-based; extended producer responsibility (EPR); availability of alternatives	
Significant changes in regime rules (D2)	take-back; right-to-repair; shared responsibility; BYO; pool system	external influences; take-back; pool system	system change (consumer versus producer responsibility)
Reduced support for dominant regime technologies (D3)	withdraw support for incumbent technologies		well-funded opposition; preemption laws; exclusion of actors; reversal of policies
Changes in social networks, replacement of key actors (D4)	replacement of key actors	network (replacement of key actors)	

Table 1.2: Creative and destructive anti-SUD foodware policies and their effectiveness. This table is based on Kivimaa and Kern's (2016) policy mix framework that categorizes sustainability transition policies as either creative or destructive. Creative policies, of which there are seven possible mechanisms, foster innovations and alternatives, while destructive policies, of which there are four possible mechanisms, erode incumbents. The table

includes the policy categories, definitions, and if the policy mechanisms in those categories are effective or ineffective as they pertain to the anti-SUD foodware sustainability transition. Only examples with published studies on effectiveness are included in the analysis.

4.1. Effective

Below are attributes or contributing factors of seven policy categories that are associated with effective SUD foodware reduction and/ or furthers the sustainability transition towards waste-free systems.

Establishing market niches/ market formation (C2)

The policy mechanism in this category commonly used and studied in the anti-SUD foodware space is public procurement. Typically noted as “green procurement” or “green purchasing”, research demonstrates that public procurement policies are effective in realizing ‘sustainability’ initiatives if the procurer is aware of and has belief in the governmental agency’s role in circular transformation (Sönnichsen & Clement, 2020) and if green procurement operations are automated into the procurement process (Lazaroiu et al., 2020). Such a policy is more effective if the ‘sustainable’ option is also cost-effective and is domestically based (Keulemans & Walle, 2017). These attitudes vary by sector, so policy effectiveness may come from tailoring the procurement plan to the government department (Halonen, 2021). Such tailoring recommendations for anti-SUD foodware policies are often localized to food service spaces and the rental of government-owned facilities for events. Ultimately, a procurer’s beliefs and participation in the transition process, as well as the cost-effectiveness and sourcing of items, are important considerations for the anti-SUD foodware norm emergence.

Public procurement is one of the more prevalent anti-SUD foodware policies in existence today (2023), used as a way to tease apart the operational changes of a new SUD foodware material or reusable foodware system, as well as provide a steady – and sometimes substantial – market for the developing innovation (Chapter 2: Heiges, 2023). That is because governments can use their procurement budgets and systems to drive the take-up of a new technology or encourage alternatives by creating demand and new markets that may otherwise not exist.

Entrepreneurial experimentation (C4)

Policies focused on providing financial resources, whether through market formation or entrepreneur experimentation, can be effective. For instance, ReThink Disposable (2019a, 2019b) has shown that grants or loans available to businesses can help them reduce their procurement costs (e.g., buying an industrial-scale dishwasher or purchasing reusable foodware) as well as decrease operational costs. Additionally, financial resources in the form of exemptions coupled with financial aid allows time for businesses and/or consumers to adapt to the new policy(ies). The City of Berkeley provides hardship waivers for businesses and accessibility waivers for low-income and/or disabled residents (City of Berkeley, 2019b), which built more equity into the rules and created more buy-in from businesses and consumers, thus aiding the unanimous approval of the policy (Ecology Center, 2023). It is this type of initial financial support that members of the Navajo Nation seek to help expand their waste management services to cover more residents and ensure that such services are financially sustainable (Skeet et al., n.d.).

Another form of entrepreneurial experimentation is supporting localized innovation, which includes customizing policies per a jurisdiction’s contexts. Contextual attributes can include engagement with the jurisdiction’s constituents, the expertise and involvement of local non-profits, a government’s resources for policy enforcement, the jurisdiction’s governance structure, the incumbents and their

relative power, and if there are regulations on campaign contributions (Clapp & Swanston, 2009; Dauvergne, 2018a; Ecology Center, 2023). Wilson et al. (2015) argue taking a local approach to waste policy governance, recommending that policies – specifically direct regulation, economic instruments, and social instruments – match the circumstances. For this local-first approach, clear goals and guiding principles are essential, as well as consistent decision-making. Another foundation of this local-first governance strategy is the ‘institutional framework’ which puts greater emphasis on the community (the institution) in which the governance strategy will reside. For instance, it is likely that the City of Berkeley was able to pass the most comprehensive anti-SUD foodware ordinance at the time, in part, because of its institutional framework of strong community activism, robust and vocal nonprofits, and the firm limits on corporate political campaign contributions (Ecology Center, 2023).

Resource mobilization (C5)

There are limited examples of resource mobilization in the anti-SUD foodware sector. The main example is venture capital. While corporate venture capital for sustainability initiatives remains at less than 15% (Döll et al., 2022), overall sustainable investment has risen to 36% of professionally managed assets (Lin, 2022) and there are now two venture capital firms exclusively dedicated to waste management, waste minimization, and the circular economy (Circulate Capital and Closed Loop Partners). Venture capital can be crucial in providing the necessary capital to launch or propel an initiative; however, it also comes with diluted equity and more decision-makers (which is not always a bad thing). According to both Circulate Capital (2022) and Closed Loop Partners (2022), venture capital in the broader anti-SUD foodware sector has resulted in plastic pollution prevention, carbon dioxide equivalent emissions avoidance, waste managed, value-added plastics, new jobs, and new capacities.

Resource mobilization was enacted for myriad operational and technological solutions during the start and height of the COVID-19 disaster, resulting in creative SUD foodware and healthcare items and processes, such as personal protective equipment. However, venture capital and corporate actors did not devote the same attention to *anti*-SUD foodware and healthcare items or processes, contributing to the proliferation of hygiene waste (Heiges & O’Neill, 2020; Chapter 5).

Influence the direction of search (C7)

Non-binding goals and voluntary actions from industry and business actors can be effective because they provide flexibility in actions and often do not entail government intervention, but their impacts are contingent on adoption (Rana, 2020). Some argue that they can be more effective than regulatory tactics because they provide autonomy to actors to decide whether and how to make changes and minimize the negative political and legal consequences of action and inaction (Chang, 2018). Such approaches can also result in more financial benefits, can be participatory, can be more transparent, and can be more democratic (Schnurr et al., 2018). Vogel (2010) argues that non-binding private regulation is as effective as national and international regulation for achieving stronger global corporate conduct. However, non-binding, voluntary actions are also fraught with skepticism and failure, as they seek to appease constituents and opposition, and do not necessarily fulfill their aims (Clapp, 2012; Soffritti et al., 2013). They can also create confusion (Harbaugh et al., 2011), can foster doubt among policymakers (Chiroleu-Assouline & Lyon, 2020), can be misleading (Lyon & Montgomery, 2015), and can over-exaggerate efficiency with weak precautionary principles guiding decision-making (Dauvergne, 2018a). The lack of coalescing evidence on the effectiveness of such approaches does not demonstrate the need to remove them but indicates that the anti-SUD foodware norm will likely not be propelled forward solely by non-binding goals and voluntary actions (Chapter 2: Heiges, 2023).

Similarly, binding governmental goals for anti-SUD foodware do not have clear indications of effectiveness. Zero Waste Europe extolls the benefits and importance of binding governmental goals as an avenue to reduce SUD foodware generation, especially if coupled with transparency measures and enforcement mechanisms (Copello et al., 2022). California's recycling rate, however, is unconvincing about the direct effectiveness of such goals: in 2011, California set a binding recycling rate goal of 75% by 2020 (Chesbro, 2011), yet in 2020, the recycling rate was 42% (CalRecycle, 2021). This demonstrated that a goal, in and of itself, is not sufficient to catalyze or progress a transition. Instead, it is the implementation to achieve a goal that is crucial. In the case of California's binding recycling rate goal, it eventually prompted the creation of the California Statewide Commission on Curbside Recycling and Recycling Markets, which influenced the design of anti-SUD foodware bills, some of which have been made into law (Quinn, 2022). So, while California's recycling rate is still low, there have been other systemwide anti-SUD foodware policy developments due to the binding government goal, thus deeming the category of policies effective (Heiges, Jackson et al., n.d.). To increase the effectiveness of binding government goals, Dauvergne (2018a) recommends to reduce issues in policy rollout, integrate structures that reinforce their use, have enforcement mechanisms or penalties for missed actions, and ensure the scope of reform is not limited.

Control policies (D1)

Direct regulation policies in anti-SUD foodware or related spaces are typically effective but can vary based on the contexts in which such policies are implemented. For instance, in one study, the use of a tax (a penalty) resulted in a larger decline in SUD bags versus the use of a bonus (a reward) (Homonoff, 2015). Another study showed that how a policy is framed, such as the use of the term, can alter effectiveness: 'tax' was more effective than 'fee' in reducing SUD bag usage among those who were not environmentally conscious consumers (Muralidharan & Sheehan, 2017). Further, a consumer with less environmental knowledge, proximity, or prioritization might require a larger incentive (e.g., a \$0.50 discount versus a \$0.25 discount) or a larger disincentive (e.g., a \$0.50 tax versus a \$0.25 tax) to participate in the pro-environmental behavior (Nicolau et al., 2022). Thus, the mechanism and the audience matter.

When China, the largest market for U.S. plastic waste and scrap, restricted the type of material it would accept, it immediately caused massive disruption in the U.S. plastic recycling system. That disruption, however, prompted actions to address the quickly mounting piles of material. As a result, today the U.S. plastics recycling system, which was not originally built methodically, is experiencing a reckoning and has the opportunity to become a more methodical, and more sustainable system. The three emerging sustainability systems are zero waste and circular economy movements, domestic processing, and eliminating problematic plastics (Chapter 4: Heiges & O'Neill, 2022a).

The timing of the consumer engagement with the control policy also matters. Market-based mechanisms (e.g., excise taxes) are more effective if consumers are presented with the financial adjustment when deciding on the item, like on the product's shelf price list or menu card, versus presented with it at the check-out counter. This is probably because at the check-out counter, unlike at the shelf, the consumer has already made the decision to purchase and is thereby less likely to change their purchase decision (Brownell & Frieden, 2009; Falbe et al., 2015; Romer & Tamminen, 2014). This also did not result in displaced consumption, meaning consumers did not travel to other jurisdictions without market-based mechanisms to consume such products (Falbe et al., 2016).

This is the theory of change behind the Berkeley Single Use Foodware and Litter Reduction ordinance: if customers are required to pay a \$0.25 charge per SUD cup, they will be discentivized to do so, but only if they are aware of the charge, which means the charge must be shown on all menus.

There are few food vendors (e.g., restaurants, cafes) currently enacting the SUD cup charge and even fewer properly advertising the charge, so it is unclear if this mechanism is effective in this specific context, especially since there are few reusable cup alternatives (Chapter 3).

Control policies can also occur much earlier in the consumption process: well before the item reaches the consumer. EPR policies, which put a tax on the product that producers must pay, are new to the anti-SUD foodware policy mix. The effectiveness of such measures on other products is well researched and includes waste improvements – and also challenges – for carpets (Choi, 2017), mattresses (Geyer et al., 2015), and batteries (Turner & Nugent, 2015). One of the lead policy architects for California’s recently passed Senate Bill 54 – Solid waste: reporting, packaging, and plastic food service ware – (Allen, 2022), Heidi Sanborn, learned from the shortcomings of the state’s carpet EPR to inform Senate Bill 54’s structure (Vonkaenel, 2022). Such learnings include supplementing EPR with reuse schemes to bolster complementary mechanisms for systems change (Copello et al., 2022).

Since EPR policies are new to the anti-SUD foodware sector, their effectiveness in spurring innovation to reduce the waste is untested, but promising. This is expected because the new regulations – in Maine, Oregon, and now California – include strong regulation and monitoring to ensure corporations abide by their new responsibilities (Heiges & O’Neill, 2021).

An additional context that influences the effectiveness of control policies is the availability of alternatives. Taylor and Villas-Boas (2015) learned that plastic bag bans coupled with paper bag fees decreased the total SUD bag consumption; however, such tactics did increase paper bag consumption, thereby offsetting some of the SUD bag consumption reduction potential. This approach also increased reusable bag consumption. Taylor and Villas-Boas’s (2015) overarching learning is that consumption rate changes are contingent on the type and price of alternative bags offered when a ban is in place.

Direct regulation and market-based mechanisms are the two most common anti-SUD foodware policy mechanisms in the United States (Karasik et al., 2020b; Upstream, 2022b). The widespread implementation of one policy type versus the other is not necessarily due to its effectiveness (even though they were) but instead because of its historical precedence, available legislative mechanisms, and industry resistance (Wagner, 2017). For instance, regarding plastic bags, the U.S.’s east coast began adopting plastic bag taxes and fees. Observing that policy trend, the plastics industry lobbied powerfully to prevent fees on plastic bags on the west coast (predominantly California), creating a statewide preemption law prohibiting anti-plastic market-based mechanisms in 2016. That law did not deter local governments in California from leveraging the other available legislative mechanisms against plastics: plastic bag bans and fees on alternative materials (e.g., paper and reusable bags). This began in San Francisco in 2007 then spread quickly to other California municipalities, even after the statewide plastic fee prevention statute expired in 2013. California then adopted a state-wide ban on SUD plastic bags in 2016 (Wagner, 2017).

There is a similar adoption trend based not on policy effectiveness but policy precedence occurring with anti-SUD foodware legislation (e.g., a charge on SUD items, requiring foodware accessories be provided by request only). This is just one mechanism in the SUD foodware policy mix, so more research is needed to not only assess its effectiveness but to understand how it does and can contribute to the anti-SUD foodware norm emergence (Chapter 2: Heiges, 2023).

Significant changes in regime rules (D2)

Regime rules are the external influences on a societal dynamic. If external influences are not addressed in policy development and implementation, effectiveness wanes (Meadows, 2008). These influences include 1) the population, like the level of education, cost of living, location, interest in

industry, and degree of economic development in the area (Li & Zhao, 2017); 2) the policy development process, such as the amount of stakeholder engagement and adequate lead time (Adam et al., 2020; Karasik et al., 2020a; UN Environment Programme, 2018); 3) the area of policy intervention such as where in the waste lifecycle it focuses (e.g., production, consumption, or disposal); and 4) if there is enforcement (Kaza et al., 2018). For greater adoption of anti-SUD foodware policies by incorporating these four external influence categories, Copello et al. (2022) recommends focusing on areas that already have reuse infrastructure in place or in progress, or places that have a demonstrated commitment to reducing their carbon footprint.

The City of Berkeley embodied the first three external influence categories with the Single Use Foodware and Litter Reduction ordinance, which contributed to its unanimous approval by the City Council and becoming a historic model ordinance in this space. However, the ordinance was lenient and nondeclarative on an enforcement strategy, which when coupled with COVID-19, likely contributed to its low compliance rate (Chapter 3). Now that the City plans to reinstate enforcement, its effectiveness is predicted to increase.

A few states have instituted take-back programs for SUD plastic bags. This means that grocery stores of a certain size and revenue are required to accept SUD plastic bags (and sometimes other plastic films) from customers, regardless of where the bag was sourced. Benefits include the ease of implementation (often a collection bin at the front of the store) and enforcement as well as low or no direct cost to the consumer. However, this creates a cost for the grocery store, is dependent on consumers bringing their SUD plastic bags to the store, and could result in increased consumption of SUD plastic bags due to the moral licensing effect (Wagner, 2017). With no official reporting on such programs, it's unclear how effective they are. However, More Recycling, commissioned by the American Chemistry Council, conducts an annual report on post-consumer plastic bag and film recycling. The report's funders and their interest are of note, but according to the 2018 report, nationwide 187 million pounds of post-consumer bags and wrap were recovered for recycling, which has annually increased (More Recycling, 2020). It is unclear if that increase is due to the efficacy of take-back programs, rising SUD plastic bag usage, or some other confounding variable. Of the 187 million pounds, 76 percent were bags and wraps, with an unknown, but not insignificant, amount collected in take-back programs. While SUD plastic bag take-back programs might not collect all bags and might not result in a 100% recycling rate, some form of collection and containment is better than them ending up in the environment, landfill, or incineration. There is, however, clearly a need to strengthen this policy mechanism.

On Berkeley's campus, Chou Hall required some suppliers to have a take-back system, which was an effective mechanism for two reasons. The first was that Chou Hall stakeholders would consistently order supplies at large quantities, making their purchases with a supplier significant. That gave them purchasing power to influence the suppliers' operations. In situations of disparate and smaller purchasers, such change requires purchasers to coordinate to have significant enough purchasing power. The second was that Chou Hall stakeholders would try to purchase from more sustainability-minded suppliers, so the supplier was either already on a path to incorporating take-back systems or such a system would align with their mission. For both reasons, Chou Hall had more take-back systems in place and therefore a reduction in waste (Schultz & Heiges, 2023).

Finally, the pool system (approved use of reusable food and beverage containers by a third party) aims to change SUD foodware regime rules by eliminating reliance on SUD foodware altogether. Pool systems reduce the amount of SUD foodware (Hekkert, Joosten, & Worrell, 2000; Hekkert, Joosten, Worrell, et al., 2000; Mahmoudi & Parvizioman, 2020), however, the overall environmental benefits of pool systems are dependent on the reusable material type, transportation types, distances to collect

and redistribute items, return rates, impact from operations (e.g., cleaning), and rate of irrevocably damaged items (Coelho et al., 2020; Mahmoudi & Parviziomran, 2020). Presently, the ability to adopt a pool system resides under the model U.S. Food and Drug Administration Food Code (National Food Retail Team, 2021), allowing health codes to determine sanitation standards for third-party services and washing. The use of pool systems is effective if health departments have adequate official language detailing the health risks, processes to mitigate them, and other relevant standards (Coelho et al., 2020; Schneider & Simon, 2022).

At the start of COVID-19, government and agency, industry, and consumer actors acted immediately out of fear and uncertainty to reduce the spread of the virus (Chapter 5). Pool systems were banned, even though they abided by the U.S. Food and Drug Administration Food Code. Pool systems are resuming across the U.S., so it will be essential to test their effectiveness in reducing SUD foodware waste to substantiate the expansion of such systems (Chapter 2: Heiges, 2023; Chapter 5).

Changes in social networks, replacement of key actors (D4)

The California Statewide Commission on Curbside Recycling and Recycling Markets was an unprecedented anti-SUD foodware political network in that, at the state level, it invited seventeen recycling incumbents and reusable advocates to collaborate on research and policy recommendations to achieve a higher recycling rate in California. This resulted in, as noted earlier, anti-SUD foodware bills that were passed in the 2021-2022 state legislative session (Quinn, 2022). The creation of a more diverse network resulted in a more robust anti-SUD foodware policy mix, thereby designating it as an effective measure.

4.2. Ineffective

Below are attributes or contributing factors of five policy categories that are associated with ineffective anti-SUD foodware policy, also known as ‘relevant failures’ (Kern et al., 2019).

Knowledge creation, development and diffusion (C1)

Anti-SUD foodware education campaigns are considered relatively ineffective. The lack of meaningful progress is due to myriad factors, with the overarching hurdle being locked-in behaviors. Many purchasing behaviors are habitual and occur subconsciously, which decreases the cognitive load needed to make routine decisions, (Seto et al., 2016). If there is nothing inherently harmful associated with a behavior, the individual will perpetuate it, solidifying it as a habit. So, since habits are done subconsciously, knowledge alone is not enough to catalyze behavior change. It must also include the contextualization of motivation (why changing behavior is important), action (how to change behavior through specific goals, increased self-efficacy), and environment-specific contexts (affordable, accessible, and community-driven policy) (Contento, 2008). This phenomenon is epitomized through ‘wishcycling’. Wishcycling is when individuals put an item in the recycling bin even when they know (or highly suspect) it will not get recycled; it is an act of environmentalism hope regardless of the increasingly common knowledge that few items – especially those that are plastic – get recycled (Heiges & O’Neill, 2022b).

Anti-SUD foodware education campaigns can aid awareness, especially when supported by consolidated scientific evidence (Dauvergne, 2018a); however, education campaigns rarely foster the coordination and collectivism needed for individual action to have meaningful impact (Oosterveer & Spaargaren, 2012). Additionally, SUD foodware harm is distanced from the consumer by efficient waste management systems, which lower a consumer’s urgency and prioritization for changing their behavior (Clapp, 2002; Princen, 2002; Worthy, 2013). Waste associated with product production is historically

obfuscated (Markowitz & Rosner, 2013; Menestrel & Rode, 2013; Soffritti et al., 2013), making it hard for consumers to protest what they do not know (Oosterveer & Spaargaren, 2012). Furthermore, even if education campaigns inform consumers on issues, consumers can only boycott by using alternatives or buycott by supporting certain products or services if they are available (Fominaya, 2020; Hilmers et al., 2012) and if they have the resources to do so (Nicolau et al., 2022). Presently there are limited SUD foodware alternatives and those that are available are more expensive, have poorer packaging features, do not meet legal requirements, are incompatible with existing manufacturing and/ or disposal infrastructure, or do not align with social values (Ghosh & Jones, 2021; Marzantowicz & Wieteska-Rosiak, 2021).

Access to resources and alternatives underscores the importance of the specific consumer's context as an indicator of consumption behavior: regardless of the education and awareness efforts, if the consumer has more pressing concerns such as personal health and safety (Corner & Randall, 2011; Nisbet & Kotcher, 2009), does not have the means to prioritize such behavior (Booking.com, 2018; O'Rourke, 2005), or if it requires compromising personal comfort (Miao & Wei, 2013), they will not engage in such behavior. Further, even with education on SUD foodware harms, consumers might purchase SUD cups because such items have emerged as a status symbol of wealth and busyness (Morales, 2019). Education alone, without accessible or affordable alternatives in a culture that values consumerism and distance from harm will continually fall short on creating meaningful change. That is, unless education campaigns are coupled with other interventions, such as control policies and establishing market niches or market formation (Rust et al., 2020).

Entrepreneurial experimentation (C4)

A policy's ineffectiveness can be judged by the impacts alternative or substituted materials have, or as Dr. Shelie Miller aptly phrased this phenomenon: "environmental Whac-a-Mole. [...] We solve one problem only to create or exacerbate another problem" (Toeniskoetter, 2022). So, while we discussed earlier that entrepreneurial experimentation policies can be effective, they also can have a shadow side.

In one study, a ban on SUD plastic bags resulted in a decrease in SUD plastic bags, but 35% more SUD paper bags were used (Stephenson, 2018). In some ways, that was the intention of the policy – to reduce SUD plastic bags – however, according to a lifecycle analysis, SUD paper bags produce 40% more greenhouse gas (GHG) emissions than SUD plastic bags (Hoffman et al., 2015; Hoffman, Guernsey, et al., 2017; Hoffman, Lyons, et al., 2017), thereby decreasing the overall effectiveness of the policy. In a recently enacted anti-SUD bag policy in New Jersey – the most comprehensive statewide ban to date since it is on all SUD bag materials – initial results show a drop in SUD bag usage, deeming the policy effective. However, online grocery delivery companies use reusable bags to abide by the policy, but do not have the infrastructure to collect and reuse those bags. That means consumers now have hundreds of reusable bags that they are not reusing (Toeniskoetter, 2022), which have a higher GHG footprint than any type of SUD bag (Gómez & Escobar, 2022). Furthermore, California's anti-SUD plastic bag ban has a thorough definition of prohibited bags, including material type, thickness, and weight-bearing capacity, but food vendors that still wanted to provide SUD plastic bags easily skirted those requirements by providing thicker bags, thus using more plastic material (Edwards & Fry, 2011; Stephenson, 2018). And those thicker bags were still only used once (Taylor & Villas-Boas, 2015).

Another example of the complex alternative material landscape is the shift from SUD foodware created by fossil fuels (e.g., plastic) to those created by biomaterials (e.g., compostable material). Both fossil fuel and biobased derived SUD foodware types are disposable, but the former slowly degrades in a landfill over hundreds of years and the latter can theoretically go in the compost bin to become soil

(Dilkes-Hoffman et al., 2019). However, bio-based products have their share of problems, which include being produced on monoculture fields with herbicides and pesticides (Dilkes-Hoffman et al., 2019); being laced with harmful chemicals to achieve water and oil repellent properties for food contact materials (Muncke et al., 2020); displacing Indigenous communities and decimating their lands (Altman, 2021); and only breaking down in industrial composters (not backyard compost bins), a facility few have access to (Dilkes-Hoffman et al., 2019; Taufik et al., 2020). Entrepreneurial experimentation is therefore not uniformly effective or ineffective and requires iterative implementation and careful consideration for unintended consequences such as ‘regrettable substitutes’ (Groh et al., 2019; Muncke et al., 2020).

It was this research and understanding of regrettable substitutes that prompted the prioritization of reusable foodware versus SUD foodware alternatives, as well as a very specific definition of alternative SUD foodware, in the Berkeley Single Use Foodware and Litter Reduction ordinance (Chapter 3).

Support from powerful groups/ legitimation (C6)

The effectiveness of third-party certifications and labels to foster anti-SUD foodware practices is debated because with so many in market, they are potentially causing confusion, dilution, or consumer skepticism in the space (Vogel, 2010); they hold limited consumer confidence due to being continually misused (Heffernan, 2022); or are criticized as either greenwashing (Heras-Saizarbitoria et al., 2020) or greencrowding (Kenway, 2022). Labels are contingent on consumer access: even if there are eco-labels on some items, if consumers do not have access to those items, such labeling systems are moot for those demographics (Hilmers et al., 2012). Further, in sustainability purchasing there is a gap between a consumer’s preference and their eventual action(s): consumers express a willingness to pay more for ‘eco’, ‘green’, ‘ethical’, or ‘sustainable’ products, yet do not do so when presented with the option (O’Rourke, 2005). A 2019 Harvard Business Review article noted that “[i]n one recent survey 65% [of consumers] said they want to buy purpose-driven brands that advocate sustainability, yet only about 26% actually do so” (White et al., 2019). Such environmental concern is deprioritized due to price, quality, style, and delivery times (O’Rourke, 2005), thereby again diminishing the effectiveness of certifications or labels. In one study labels only influenced more environmentally-based purchasing decisions when the consumer was already ambivalent about what they wanted to purchase and were presented with both an eco-label (a red, yellow, or green marker indicating how harmful consumption of each fish type was) and an educational poster (indicating mercury level in each fish type) (Hallstein & Villas-Boas, 2013). Like education campaigns, certifications and labels, as a means of legitimation, are not considered particularly effective and should therefore be implemented in conjunction with other anti-SUD foodware policies.

Significant changes in regime rules (D2)

Some policies perpetuate the concept that consumers must be the sole driver for environmental action, not producers, meaning system change is not occurring. For instance, policies that place additional fees on consumers (e.g., SUD bag charge) or require consumer action (e.g., BYO, right-to-repair) do not address the source of the issue: the subsidized overproduction of SUD foodware without viable, affordable, and accessible alternatives. Fees on consumer action are considered effective measures, however, only if producers do not also participate in waste reduction strategies. For instance, if an anti-SUD cup policy aims to reduce SUD cups at cafes and is contingent on consumers bringing their own cup versus providing reusables for on-site dining or a third-party service for taking a reusable cup to-go, the sustainability policy will plateau once all early adopters participate (Bailey, 2017; Tencati et al., 2016). Further, such a downstream, consumer-centric approach makes policy more vulnerable to regime and landscape shocks, such as COVID-19. During COVID-19 producers were still producing SUD

foodware with the same materials, but producing more of them because the downstream anti-SUD foodware policies were paused (Becker et al., 2020; Chapter 5). System change requires taking a systems lens to think about change.

Reduced support for dominant regime technologies (D3)

Reduced support for dominant regime technologies (e.g., removing subsidies) is categorized as ineffective in the instances that it catalyzes well-funded opposition by dominant regime technologies (Markowitz & Rosner, 2013; Soffritti et al., 2013), thus stymieing the norm's progression. However, industry resistance is an indicator of norm emergence advancement because it has reached a threshold of being taken seriously by the opposition.

Resistance responses from industry come in many forms, such as corporations that lobby for full or partial preemption laws. Preemption laws are enacted by higher governments and eliminate local government authority. According to Ballotopia's (2022) running list of states with preemption measures on plastic bags, 14 states have such laws in place, 13 states prohibit local governments from regulating the use of plastic bags (a 'ban on bans') while one state, California, implemented a statewide ban on plastics bags.

Opposition can also arise not from inherent differences in interest or values – such as from SUD foodware producers – but because the policy was not co-developed and thus intentionally or unintentionally exclusionary. That was part of the polarizing anti-SUD plastic straw campaign. Local campaigns demanded the removal of SUD plastic straws at food businesses (Upstream, 2022a), while disability advocates demanded the availability of straws to ease their consumption of beverages and not be excluded (Kessler, 2019). It is not that disability advocates were pro waste; it is that they wanted equitable practices and to be included in the policy development process (Wong, 2018). Policies were amended to require that SUD plastic straws not be given automatically but be available by request or at a self-serve station (Carrillo, 2021; Ecology Center, 2023).

Further, opposition can also appear and cause impacts after policies are enacted, such as in the reversal of policies. For instance, in 2011 the Obama administration enacted a policy for national parks to voluntarily ban the sale of SUD plastic water bottles, which was adopted by almost two dozen national parks. However, in 2017 the Trump administration, through the encouragement of the International Bottled Water Association (a trade association of over 100 plastic bottled water brands), reversed that policy (Aubrey, 2017). In 2022, under the Biden administration, the Department of the Interior will require all national parks and public lands to phase out SUD plastic bottles by 2032 (Hauser, 2022).

Finally, if support for dominant regime technologies is not reduced with viable and mature alternatives in place, and if large-scale disruption occurs, dominant regime technologies can swiftly regain power. This was clearly demonstrated in the beginning months of COVID-19 when the plastics industry engaged in what could be considered disaster capitalism, by taking advantage of the weaker systems, fear-based decision-making, and general uncertainty caused by the pandemic and gaining a stronghold as a solution to contagion abatement (Chapter 5). That collusion and thus increasing the prevalence of SUD items, contributed to the proliferation of hygiene waste.

5. The Four Chapters

In the following four chapters, I and my co-authors take you through different avenues of analysis for a sustainability transition towards waste-free systems.

In Chapter 2, I begin with an overview of the myriad policies in the field of anti-SUD foodware, including what anti-SUD foodware policies are and how they have evolved over the decades through the anti-SUD foodware norm emergence. While I do not posit that the anti-SUD foodware norm has fully emerged – it is not in a taken-for-granted state – I do argue that anti-SUD foodware policies have passed a critical threshold of proliferation and adoption. Of the four sustainability transition frameworks, this paper best exemplifies ‘where’: where policies were catalyzed based on specific contexts. This blueprint is an orientation of all the policies in the U.S., thereby positioning what policies have worked, where there are gaps, and areas of opportunity to further the sustainability transition towards waste-free systems.

In Chapter 3, we focus on a specific policy: the Single Use Foodware and Litter Reduction ordinance in Berkeley, California. This historic policy was adopted in January 2019, and included three phases and multiple legislative mechanisms, to progressively decrease the amount of SUD foodware discarded in the city. Analyses come from a longitudinal observational quantitative survey. This chapter is grounded in the actors (the ‘who’), who both breathed the ordinance into existence and have failed to hold it up because of COVID-19. A hyperlocal and thorough examination of one policy within the larger sustainability transition towards waste-free systems helps inform what is needed, by whom and when, to create a policy, and how the lack of engagement after implementation can substantially impede policy effectiveness.

In Chapter 4, we go to the next policy scale, the national: the U.S. In 2017 and 2018 China announced and then implemented Operation National Sword, which massively reduced the amount of plastic waste it accepted. This caused disruption across the U.S. plastics recycling system because prior to Operation National Sword, China received roughly 70% of U.S. plastics waste (Brooks et al., 2018). This paper demonstrates the impact of one country’s policy on another country’s waste-free operations and since the U.S. plastics recycling system was so disrupted, it is ready for a new – hopefully more sustainable and methodical – regime to emerge. The immediate action and then delayed solution implementation are examples of ‘how’ the transition to a waste-free system was both disrupted but can also gain strength through this ‘reckoning’.

Finally, we discuss the macro level, with a reflection on COVID-19, waste, and the actors responsible for influencing the new type of waste (hygiene waste) and the exorbitant amount of waste generated during that period, specifically in the U.S. Like the following three chapters, it centers policy with regards to waste generation, but focuses on waste generation when such policy is paused. COVID-19, an unprecedented disruption in scale, conveys the ‘when’ of the transition and that when a transition is as precarious as the waste-free system pre-COVID-19, it can be derailed dramatically.

Each chapter mentions the effectiveness of the policy(ies) being examined. While they do not necessarily use the terminology or frameworks as explained above, each analysis of effectiveness influenced the creation of those frameworks and are direct examples of the frameworks holding true. The Conclusion chapter focuses less on a summary of the preceding chapters – though it does provide that – and more of a reflection-turned-thought-experiment on an underacknowledged yet potentially crucial aspect of sustainability transitions to waste-free systems: a social imaginary.

6. Conclusion

This corpus of research advances sustainability transition theory and discard studies. For sustainability transition theory, we propose and apply new dimensions of sustainability transition frameworks to align and further burgeoning research in the field. This means that we are tracking the process of instigating a sustainability transition and investigating how the transition is occurring.

Additionally, we substantiate the need for policy as both a catalyst and perpetuator of sustainability transitions. We provide new insight into relevant actors as well as propose the inclusion of traditionally excluded actors. Finally, we contribute to the prominent MLP framework by elucidating the potential of multiple, co-existing regimes, and thus advocating for a revision of the de-alignment and re-alignment pathway. For discard studies, I name and outline the emerging anti-SUD foodware norm; we provide a rare research study on the effectiveness of an anti-SUD foodware policy; we demonstrate that we are in a unique time to critically evaluate the preexisting U.S. plastics recycling system and thereby make it more methodical and sustainable; and we categorize the new and pervasive COVID-19 waste stream – hygiene waste – including how to curb such waste in future disasters.

Sustainability transitions research is nascent in coalescing on defining what constitutes a ‘complete’ transition (Köhler et al., 2019). However, in the following four chapters, I, and my collaborative researchers argue that the importance of a sustainability transition is not its completeness, but its ongoing effectiveness. A transition can be complete, but it might not have obtained its goal; the situation might remain unsustainable. If a transition is benchmarked on its effectiveness, then there is more opportunity for evaluation on the components that catalyzed the transition. This introduction therefore aimed to critique and recommend changes to sustainability transition dimensions as developed through waste-free transition analyses, while the four chapters aim to critique and recommend changes toward a waste-free transition through sustainability transitions frameworks.

Chapter 2

Eliminating Single Use Disposable Foodware: An Emerging and Cascading Norm

This chapter was previously published (Heiges, 2023)

Jessica Heiges

Abstract

Over the last few decades, varied policies have developed nonlinearly to reduce the amount of single use disposable (SUD) foodware generated and disposed of in the U.S. The increasing prevalence of such policies indicates a sustainability transition and the potentiality that this emerging norm is gaining societal embeddedness. The different types of policy mechanisms adopted both support SUD foodware alternatives and erode SUD foodware incumbents. To better understand the variety of policy mechanisms in the anti-SUD foodware norm emergence, I present a case study of the unprecedented Single Use Foodware and Litter Reduction Ordinance adopted in Berkeley, California in 2019. I demonstrate that the anti-SUD foodware norm emergence is in the ‘cascade’ phase, in part due to the different types of policy mechanisms in place. By adding the policy mix framework to the norm emergence theory, I provide a quantification and comparability to policy analyses to progress policy-based sustainability transitions.

1. Introduction

Sustainability transitions are increasingly grounded in policy because of a policy’s ability to influence technological change (Rogge & Reichardt, 2016), the complexity and multiple actors in the system (Flanagan et al., 2011), and the difficulty of destabilizing incumbents (Köhler et al., 2019). One framework for analyzing policy transitions is norm emergence. Unlike other, more traditional policy transition frameworks that center discussions on the specific instruments (Flanagan et al., 2011), their ‘coherence’ (Huttunen et al., 2014), or their political dynamics and processes (Johnstone et al., 2017; Rogge & Reichardt, 2016; Uyerra et al., 2016), norm emergences include the wider context of informal rules and the reflective attributes of assessing progress and needs during the transition process from norm to policy codification (Huitema et al., 2018).

Single use disposable (SUD) foodware is experiencing a sustainability transition. SUD foodware has become a part of modern-day consumption across cultures, regions, income levels, and governance structures (Heidbreder et al., 2019). The consumption of SUD foodware is linked with prosperity (Morales, 2019), convenience (Risch, 2009), affordability (Freinkel, 2011), limited or nonexistent alternatives (Dilkes-Hoffman et al., 2019; Wozniacka, 2020), and hygiene (Thompson, 2020). Its development was both maniacal (Gies & Soto, 2013) and harmless (Meikle, 1997); it both eases pressure on natural resources (Freinkel, 2011) and it exploits natural resources (Hamilton et al., 2019). Foodware

is only one category of SUDs: other categories include medical equipment like masks and gloves, cosmetics such as daily disposable contact lenses, and generalized packaging like what encases a toy.

The main materials associated with SUD foodware are glass, metals, plastics, cardboard, paper/fiber, and mixed or composite materials (Risch, 2009). These can be bottles, cups, cartons, pouches, boxes, clamshells, trays, wraps, utensils, bags, straws, stirrers, and napkins, to name a few. They can be provided by a retailer automatically or can be requested or picked up at a self-serve station. They might be recyclable or compostable, but only if approved by local waste service providers, of which standards vary substantially within the U.S. (Mouw et al., 2020). They also might be made from reclaimed materials. No matter their base material, or when or how they are provided, SUD foodware are defined by their intended number of uses: one. So, while some plastic forks and takeout containers can theoretically be washed and reused, that was not their purpose when designed, manufactured, and provided. I intentionally focus on all SUD foodware material types versus the more well-used category of anti-plastic because of the below mentioned proliferation of both SUD foodware items and anti-SUD foodware regulation across myriad materials.

This article outlines the emergence of an anti-SUD foodware³ norm: a policy-based sustainability transition from previous wasteful practices toward the anti-SUD foodware social imaginary, which is a waste-free future, collectively defined by the zero waste (Zero Waste International Alliance, 2021) and circular economy movements (Ellen MacArthur Foundation, n.d.-a). Framing the transition through a norm emergence elucidates where we are on this pathway to more sustainable and just waste-free systems and thereby identifies what policies need to be enacted. I begin by describing the data sources and the method for analysis, including the policy mix framework and norm emergence theory. From there, I outline which policy mechanisms are used in the current U.S. anti-SUD foodware norm emergence. To contextualize that and to elucidate the norm to policy nuances, I dive deeply into an analysis of one specific anti-SUD foodware policy, the City of Berkeley's 2019 Single Use Foodware and Litter Reduction ordinance (henceforth the "Berkeley ordinance"). I end with an examination of how the Berkeley ordinance elucidates the larger anti-SUD foodware norm emergence, examples of policy comparisons through the policy mix framework and norm emergence theory, and recommendations for anti-SUD policies and future research.

This research uniquely furthers the quantification, and thus comparability, of the norm emergence theory by incorporating the policy mix framework. It also introduces the concept of categorizing an entire body of materials and products (anti-SUD foodware) to coalesce understanding, research, and action to progress the anti-SUD foodware norm emergence. As part of that analysis, I argue that the anti-SUD foodware norm emergence in the U.S. is in the 'cascade' phase. I substantiate that argument with a case study on Berkeley's ordinance, which was one of the first multi-mechanism policies in the U.S., which are now being adopted across the country (Upstream, 2022b). Such a detailed review of anti-SUD policy is rare and needed (Diana et al., 2022). While this case study and research are focused on the U.S., I initiate the opportunity to compare anti-SUD foodware policies across jurisdictions and geographical scales through the combined norm emergence theory and policy mix framework (e.g.,

³ 'SUD foodware' is a term especially associated with the City of Berkeley and its historic ordinance. This field of categorization and analysis is emerging, so the term is presently not widely used.

the European Union's Directive 2019/904). Or, as a way to inform components of the Global Plastics Treaty, which is presently under negotiation (UN Environment Programme, 2022).

2. Material and Methods

For this study, I apply the analytical framework of policy mixes for sustainability transitions to provide novel insight into the anti-SUD foodware norm emergence. The norm emergence theory, as described in more detail in the next section, does not contain the quantification of policy comprehension that policy mixes provide. I therefore propose and apply the integration of the policy mix framework into the norm emergence theory to elucidate where the anti-SUD foodware emergence is in the norm emergence lifecycle.

There are numerous, disparate anti-SUD foodware policies across jurisdictions in the U.S. That array of policies can be described as a policy mix. Policy mixes are the myriad and complex multi-actor and multi-level policies (Flanagan et al., 2011) and how they interact with varying objectives, instruments, and processes (Köhler et al., 2019). Increasingly, policy mixes are associated with the ushering in of sustainability transitions due to their role of fostering innovation and destabilizing locked-in structures (Kivimaa & Kern, 2016); policy mixes create a reconceptualization of the instruments and their interactions, thus creating more deliberate sustainability transitions (Rogge et al., 2017). Further, policy mixes can inform policy design to integrate new policies into preexisting contexts and political landscapes because no policy is adopted in isolation (Kern & Howlett, 2009) without a "messy reality" (Kern et al., 2019, p.215). The anti-SUD foodware policy mix, which is cross-sector, cross-level, and cross-administrative domains, demonstrates governmental efforts to foster sustainability transitions, albeit in an uncoordinated manner. I therefore leverage a policy mix framework to better understand what anti-SUD foodware policies exist to inform the status of the norm in the norm lifecycle and clear opportunities for more coherent and consistent policymaking (Dijk & Kivimaa, 2020) to better support the anti-SUD foodware norm transition.

I apply Kivimaa and Kern's (2016) policy mix as the framework for analysis. Kivimaa and Kern (2016) argue that there are two main categories of policies within a policy mix: creative and destructive. Creative policies are those that support localized innovations progressing toward sustainability, or in this case, toward an anti-SUD foodware social imaginary. Such policies transform or align toward a common goal and incentivize participation. Destructive policies aim to erode the incumbents and other contributing factors of the stable, preexisting locked-in system of unsustainable SUD foodware production, consumption, and disposal. Those are policies that restrict usage of a SUD foodware item or reduce support for the producer-dominant regime.

Kivimaa and Kern (2016) take a wide perspective on the definition of policy and include items that foster change, such as voluntary agreements, even if they are not specifically codified into legislation. Bernstein (2001) might argue that this lack of translation to direct policy is not representative of codification, however, I align with Clapp and Swanton's (2009) position that fostering formal or informal change is a demonstration of the norm diffusion, specifically at a norm lifecycle's 'tipping' point.

Anti-SUD foodware policy data were gathered from two main sources: The Nicholas Institute for Environmental Policy Solutions at Duke University's Plastic Policy Inventory and Upstream's (2022) Policy Tracker. These two institutions have independently monitored and compiled waste reduction

policies. The Nicholas Institute for Environmental Policy Solutions at Duke University, a research institute, created the Inventory through a rigorous methodology, including reviewing legal databases, scientific search engines, grey literature, and Google News (Diana et al., 2022). Upstream, a U.S.-based nonprofit, has not published their Policy Tracker methodology, but is known as a preeminent institution in tracking and advocating for policy that promotes reuse and source reduction. Besides the rigor and transparency in methodology, the main difference between the two databases is the Plastic Policy Inventory focuses on plastic policy (Karasik et al., 2022b) and while the Policy Tracker is material agnostic, it focuses only on anti-SUD foodware policy in the U.S. (Upstream, 2022b).

To gain contextual perspective, I supplemented these databases with industry news (e.g., Waste Dive, Resource Recycling, Restaurant Business) and grey literature, which provided timely updates on relevant policies in the U.S. There is a known lack of rigorous assessments of waste reduction policies (Diana et al., 2022). The studies that provide such insight are an examination of a specific product – microbeads (Dauvergne, 2018a), bags (Clapp & Swanston, 2009; Taylor & Villas-Boas, 2015), straws (Wagner & Toews, 2018) – and how a policy has influenced waste tonnage (Brooks, 2018; Heiges & O’Neill, 2022a) or the development of other policies (Alger & Dauvergne, 2020; Clapp & Swanston, 2009; Dauvergne, 2018a; Wagner, 2017; Wagner, 2020). I introduce the categorization of all SUD materials and products associated with food and beverage consumption – SUD foodware – because of the increase in policies that are material and product agnostic (Karasik et al., 2022b; Upstream, 2022b). I examine these policies as they relate to preexisting and emerging policies versus waste tonnage because of the inherently complex, obfuscation, and incompatible tonnage data. Further, while there is one study on SUD plastic bags as a norm emergence, there is only that one study, and it was released in 2009 (Clapp & Swanston, 2009). So, while some publications give important historical insight into anti-SUD foodware policy (Alger & Dauvergne, 2020; Clapp & Swanston, 2009; Dauvergne, 2018a; Wagner, 2017; Wagner, 2020), in general, publications were not an appropriate source of data, methods, or theory on the developing, introduced, and recently enacted anti-SUD foodware policies in the U.S.

To obtain results, I assessed the data gathered from the different sources, first through the policy mix analytical framework. Based on the specifics of each anti-SUD foodware policy, I categorized them across the creative and destructive policy types, and provided examples. I used that quantitative assessment to translate results into the qualitative norm emergence theory, thus substantiating my argument on the current standing of the anti-SUD foodware norm emergence.

To validate this approach, I applied it to a specific multi-mechanism anti-SUD foodware policy: the Berkeley ordinance. The case study begins with a detailed examination of the components necessary to the policy’s adoption (norm emergence) then examines the components of the multi-instrumental policy (policy mix). For the case study, I gathered data from interviews and by reviewing documents produced by the city and coalition who mobilized to create and pass the policy. I interviewed six people over four years. These individuals were all part of the coalition, holding different politically and societally influential roles.⁴ All interviews were open-ended, focused on better understanding the actors,

⁴ The roles of the six interviewees were an elected City of Berkeley official, a City of Berkeley staff member, a City of Berkeley Zero Waste Commissioner (voluntary role), and three employees (from individual contributor to executive director) from three separate organizations focused on SUD foodware reduction policy and action. The three organizations span their focus from Berkeley to the entire U.S. All interviewees were guaranteed anonymity per the interview contract and stipulations in the University of California, Berkeley’s Center for Protection of Human Subjects. The approved protocol is #2020-01-12895. The author conducted these interviews.

conditions, and strategies to create and pass the policy. All interviews were 30 minutes to one hour. I interviewed each person at least once, and one person 15 times. The city and coalition documents reviewed were City Council meeting minutes, the City's Zero Waste Commission meeting minutes, reports compiled by the Zero Waste Commission, drafts of Berkeley's ordinance, coalition meeting minutes, and the Ecology Center's (one of the coalition members) new online toolkit of their process in developing and passing the Ordinance (Ecology Center, 2023). All documents are publicly available and cited accordingly.

3. Theory

Norms are shared behaviors that can be unwritten but are expected and socially enforced (*Social Norms*, 2001). They perpetuate values and guide social order, meaning they influence behavior with or without an individual's awareness of that influence (Miller & Prentice, 2015). Norms do not emerge overnight and while they might be unwritten, they can be codified through policy. The translation from norm to policy is not linear nor necessarily replicable (Alger & Dauvergne, 2020; Clapp & Swanston, 2009; Loges & Jakobi, 2019). Some define the official adoption of norms – which are shared standards of appropriate behavior (Cialdini & Trost, 1998) – on the international scale, as the codification of it through international agreements (Bernstein, 2001); however, others argue that such adoption occurs at the national and subnational level (Clapp & Swanston, 2009).

According to Finnemore and Sikkink (1998), the typical journey from norm emergence to policy implementation has three phases. Norm emergence begins with 'norm entrepreneurs' bringing attention to a social or environmental issue. The actor frames the issue to convince norm leaders (political actors) to sponsor action to address the norm by putting it on their agenda. Once an ambiguously defined critical mass of norm leaders is reached, known as the 'tipping point', the norm is in the second phase of the lifecycle: the norm cascade. In this second phase, norm adoption occurs more quickly out of pressure to conform, obtain legitimacy, and enhance esteem; policies proliferate. The final stage of the norm lifecycle is norm internalization, where the norm becomes commonplace, taken-for-granted. U.S.-based examples Finnemore and Sikkink (1998) provide are the woman's right to vote, the abolishment of legalized slavery, and medical personnel's immunity during war.

In this article, I combine Finnemore and Sikkink's (1998) framework with Clapp and Swanson's (2009) framework of norm emergence and overlay Kivimaa and Kern's (2016) policy mix framework to better understand the anti-SUD foodware norm. I focus on the second phase, the 'cascade' to apply the policy mix framework, then discuss the status and potential options for 'internalization'. This is not a discussion on why the emergence occurred. It is instead an analysis on the overall norm lifecycle so we can learn from it and thereby strengthen it, especially amid times of disruption in the norm's lifecycle, which caused fear, uncertainty, and empowered vested interests in a countermovement, as seen in COVID-19 (Heiges & O'Neill, 2020; Heiges, Bourque et al., n.d.).

4. Results

The second phase of the norm life cycle is the norm cascade. The cascade is reached after a 'tipping' point: an ambiguous threshold of "broad norm acceptance" or when "a critical mass of relevant state actors adopt the norm" (Finnemore & Sikkink, 1998, p.895). This scenario, also known as norm diffusion (Dauvergne, 2018a), is the proliferation of policies that aim to codify the emerging norm. That

translation of a norm into policy varies spatially and temporally and is never linear (Alger & Dauvergne, 2020; Clapp & Swanston, 2009; Loges & Jakobi, 2019).

Norm cascades are a temporal phenomenon and the reason for the norm to translate into policy can vary substantially. Between the 1970s and 2000s, anti-SUD foodware policies emerged for specific foodware items or materials. For instance, Clapp and Swanston (2009) give the example of anti-SUD plastic bag policies – arguably a ‘norm cluster’ (Winston, 2018) within the anti-SUD foodware norm emergence. The policies in high income countries were predominantly taxes adopted from global public pressure stemming from public health and safety concerns. In lower income countries, SUD plastic bags were mostly banned due to local environmental concerns exacerbated by limited municipal solid waste (MSW) infrastructural capacity. This uncoordinated geographical difference is common, often a result of the inconsistent translation of norm to policy based on local politics, cultures, and economic factors (Alger & Dauvergne, 2020). However, scattered policies can coalesce. As Dauvergne (2018) notes, that can come “when scientific evidence of harm is consolidating, when activism is intensifying, and when political and corporate resistance is relatively weak” (p.1). That appears to be what happened with the anti-SUD foodware movement: increased research on the harms of SUD foodware production, consumption, and disposal; the rising prominence of activist organizations campaigning against SUD foodware; government representatives championing anti-SUD foodware progress; and the rare weakness of corporate resistance to those campaigns and measures.

Even with the clear increase of opposition to SUD foodware, the status of the anti-SUD foodware norm emergence within the norm lifecycle has not been critically analyzed. Below I conduct that analysis by examining current anti-SUD policies in the U.S., with relevant examples, categorized as creative or destructive policies. I exclude the policy mix categories that do not have an anti-SUD foodware policy in the U.S. Through this framework I demonstrate that the norm is in the cascade phase. A summary of the policy mechanisms with examples is shown in Table 2.1.

4.1 Creative Policies

For the knowledge creation, development and diffusion (C1) category, *educational policies*, used to create ‘pro-environmental behavior’, are an information tool that requires little to no government involvement and stresses the importance of the individual’s active role in the aggregate to achieve collective change (Oosterveer & Spaargaren, 2012). If educational policies focus on informing the consumer, *knowledge creation policies* focus on informing policymakers. These policies might include the creation of commissions or research consortiums by allocating resources to better understand emerging systems or the detriments of preexisting ones.

Another component of knowledge creation is *generated and disseminated resources* for food businesses to increase and improve their anti-SUD foodware practices. These resources are often guides – mandated by policy and created by government staff – to reduce additional work needed by food businesses to comply with policy and to standardize information and practices across a jurisdiction. Examples include procurement guides that list SUD and reusable foodware that are compliant with the jurisdictional anti-SUD foodware policy.

Finally, *data transparency* policies aim to correct asymmetrical information between consumers, producers, waste service providers, and government representatives to inform action and preferences

(Silva et al., 2021). Examples include publicizing data on export material type(s), amount(s), and destination(s).

The aim of establishing market niches/market formation (C2) policies is to provide additional and sometimes necessary support to increase demand for niche-innovations. That can be through “shielding, nurturing and empowerment” of niche-innovation development (Smith & Raven, 2012, p.1025); fostering greater ease for an innovation to enter the supply chain, join the social, political, economic, and institutional network, and benefit from or contribute to knowledge (Jacobsson & Bergek, 2011); or by making an emerging technology price comparative with the existing technologies through ‘price-performance improvements’ (Kivimaa & Kern, 2016).

Economic policy instruments focus on providing incentives for consumers to engage in less-wasteful practices. One example is discounts for consumers when they use their own reusable bag, cup, or food container (Slafter, 2019). Another example is deposit return schemes where customers pay a deposit then receive the value of the deposit once it is returned. A third form of new market formation policies require governments to purchase specific items under *public procurement mandates*. These policies aim to aid the creation of a new market by providing a steady and substantial stream of revenue.

The entrepreneurial experimentation (C4) category are policies releasing government funding to diversify offerings and capabilities in preexisting firms and encourage niche-innovations. Most resources for entrepreneurial experimentation are not specific to anti-SUD foodware initiatives but indirectly support the norm emergence. *Diversifying offerings and capabilities* in preexisting firms means financial support for new MSW infrastructure or technology. *Financial investments* encourage niche-innovations through grants and loans. They specifically support alternative systems, like reusable container pilot programs, versus expand or diversify preexisting firms.

Support from powerful groups/ legitimization (C6) is a grouping of policies that leverages outside sources to bring credibility to the norm. The main instrument in which to do so is *third-party verifications or certifications*. Adoption of verifications and certifications by producers help quantify components of a product that might be less environmentally harmful (Prakash & Potoski, 2006) and thus inform consumers about their consumption’s environmental (and sometimes social) impact (Brach et al., 2018); however, they can also be used to create product differentiation and additional marketing opportunities (Chen et al., 2018), or nefariously used as greenwashing (van der Ven, 2019).

Some policies seek to influence the direction of search (C7). Norms are not always translated into policy but do result in informal actions (Clapp & Swanston, 2009; Kivimaa & Kern, 2016). Those actions can be from industry, such as non-binding goals and voluntary actions. Actions can also be from consumers and activist organizations, such as demonstrations. *Non-binding goals and voluntary actions* are private actors declaring noncommittal goals about improvements they will make with a long-term horizon. In the past decade there has been a proliferation of non-binding goals and voluntary actions from large corporations in the SUD foodware supply chain. Consumer- and activist organization-lead influences on the direction of search are through *demonstrations*, such as large boycotts, buycotts, marches, beach cleanups (Schnurr et al., 2018), and communication campaigns that create two-way conversation with companies to encourage the elimination of SUD foodware practices (Howard, 2016).

4.2 Destructive Policies

The first category of destructive policies is control policies that internalize environmental costs (D1). Bans are *command-and-control* mechanisms that directly regulate behavior by reducing consumer choice. Examples of such anti-SUD foodware policies include bans on material type (e.g., plastic) or on foodware type (e.g., films) (Slafra, 2019). Taxes and fees are *market-based* mechanisms that incentivize behavior change through raised prices which maintain consumer choice but can decrease consumption because heightened prices mean some people are no longer able to afford it⁵ or it dissuades people to purchase at the higher price (Halliday, 2015). Bans on certain SUD foodware types are often considered cheaper to monitor but criticized for limiting consumer freedom of choice and only displacing consumption instead of decreasing it (Taylor & Villas-Boas, 2015). Some taxes are presented at the point of sale, while other fees and charges are posted before consumption decisions are made, such as on bulletins, menus, or the sticker (or shelf) price. Another way to approach direct regulation, but without substantial pushback from consumers, is through *choice architecture (nudges)* (Wagner, 2017). Nudges aim to alter behavior through preferential selection versus outright bans. For instance, providing paper bags automatically and only providing plastic bags if the consumer asks for them (Wagner, 2017).

Quantity limits are policies that limit production by capping a pollution quantity or price. This mechanism is often harder to implement because the crucial information to determine those amounts are usually unknown, such as consumer demand elasticity and the pollution damage from one item in question (e.g., a plastic bag) (Taylor & Villas-Boas, 2015).

Finally, a control policy that internalizes environmental costs are *material requirements* which can come in two forms: the recycled content amount and the material used in SUD foodware. For recycled content amount, that means the amount of post-consumer recycled (PCR) content used in a paper bag or water bottle, for instance. Material requirement policies often stipulate the minimum amount of PCR, only Biodegradable Products Institute (BPI) certified or Compost Manufacturing Alliance (CMA) certified compostable material, or SUD foodware without per- and polyfluoroalkyl substances (PFAS).

There are a few policies that aim to create significant changes to regime rules (D2). Regime rules are the underlying social, political, and institutional rules that govern a regionalized society (Geels & Schot, 2007). Examples of anti-SUD foodware policies that aim to significantly change regime rules include take-back or right-to-repair structures, shared responsibility policies, Bring Your Own (BYO) mandates, and pool systems.

Take-back or right-to-repair structures are those that empower the consumer to send back their broken item to the corporation for them to fix it or for the consumer to fix their broken item (or pay someone to fix it) via manuals and tools (O'Neill, 2019).

Shared responsibility policies aim to reduce and shift the burden of waste management from local jurisdictions and consumers to producers. This includes extended producer responsibility (EPR) policies that require producers to financially contribute to a fund based on the amount of a specified material they produce. That fund is then distributed to jurisdictions to support their waste management practices.

⁵ Since some consumers are no longer able to afford an item at the heightened price, it is unclear if consumer choice is maintained in all market-based mechanisms.

BYO schemes are systems change policies that require customer action and participation. BYO relies on the customer to bring their own cup, food container, bag, utensils, etc. to prevent packaging waste. The food business refills the customer's item, but may reject it (e.g., if it is too dirty) or not touch it (e.g., customers bag their own groceries).

A similar policy to BYO in that it fosters the reuse of an item, but one that does not rely on customers remembering to bring their own, is a *pool system*. A pool system is a third-party or in-house system that manages the collection, washing, and redistribution of reusable items. The system can be managed (operated by a governmental entity), unmanaged (operated by a private entity), or individual (operated in-house).

In the final grouping of policies – changes in social networks and replacement of key actors (D4) – the aim is to *remove incumbent actors* from key decision-making and influential roles, so there is greater support and opportunity for niche-innovations. The lack of government sanctioned organizations or networks charged with systems change in the anti-SUD foodware space has caused the vacuum for activist organizations to mobilize. Such mobilization includes research and policy advocacy.

The policy mix framework demonstrates all policy types represented in a norm codification, most specifically where a norm to policy translation might be overweighed or underrepresented in certain policy types. However, a policy mix does not demonstrate the nuances within each policy type, which can impact that individual policy's effectiveness and/or the effectiveness of the policy category at large. Schmidt and Sewerin (2019) address this shortfall through analyzing the policy's intensity. A policy's intensity is how structurally sound the policy is, conveyed through a coding-based approach of its objectives, scope, integration, budget, implementation, and monitoring (Schaffrin et al., 2015).

Policy Mix	Example(s) of Policy Mechanism in the Anti-SUD Foodware Norm Emergence within the U.S.
<i>Creative Policies</i>	
Knowledge creation, development and diffusion (C1)	Educational; knowledge creation; generated and disseminated resources; data transparency
Establishing market niches/market formation (C2)	Economic policy instruments; public procurement mandates
Entrepreneurial experimentation (C4)	Diversifying offerings and capabilities; financial investments
Support from powerful groups/legitimation (C6)	Third-party verifications or certifications
Influence on the direction of search (C7)	Non-binding goals and voluntary actions; demonstrations
<i>Destructive Policies</i>	
Control policies (D1)	Command-and-control; market-based; choice architecture (nudges); quantity limits; material requirements
Significant changes in regime rules (D2)	Take-back; right-to-repair; shared responsibility; bring your own schemes; pool system
Changes in social networks, replacement of key actors (D4)	Remove incumbent actors

Table 2.1: The policy mix of the anti-SUD foodware norm emergence in the U.S. This table represents policy mechanisms that are part of the anti-SUD foodware norm emergence, which have been enacted in the U.S. These are local or state policies, not federal policies.

5. Discussion

5.1 Case Study: The City of Berkeley's Single Use Foodware and Litter Reduction Ordinance

Within the anti-SUD foodware norm emergence, I have now established the mix of creative and destructive policies. Below I analyze the policy mechanisms through a case study approach to put the framework and theory into context, especially as it pertains to the hyper-local and nonlinearity of norm codification. The case study is of Berkeley, California's Single Use Foodware and Litter Reduction ordinance. It is a case study of norm emergence and norm cascade; how norm entrepreneurs coalesced to create a comprehensive and historic anti-SUD foodware policy, including how and why specific mechanisms were included in the enacted policy. While this is a single policy at the local level, it is representative of the anti-SUD foodware policies introduced and enacted in the U.S. in the early 2020s (Karasik et al., 2022b; Upstream, 2022b).

In 2016, after Donald Trump was elected U.S. President, a coalition of community-based anti-SUDs activists met to generate local momentum based on fear of potential environmental regulation rollbacks (Ecology Center, 2023). That coalition was comprised of local nonprofits (Global Alliance for Incinerator Alternatives, Greenpeace, Plastic Pollution Coalition, Surfrider Foundation, The Story of Plastic, and Upstream), community members, one of the city's recycling service providers (the Ecology Center), and government representatives (a City of Berkeley staff member, the Zero Waste Commission, and Councilmember Sophie Hahn). The coalition – spearheaded by Martin Bourque, the Executive Director of the Ecology Center⁶ – decided to focus on combating SUD foodware items due to their rising prevalence as litter and thus city and county expense for abatement, as well as their harm to environmental and human health. The coalition took aim in the City of Berkeley, California, home to the University of California at Berkeley and a historically liberal and pro-environmental action city, where curbside recycling got its start in 1973, expanded polystyrene (Styrofoam) was banned in 1990, and SUD plastic bags were banned in 2012 (Ecology Center, 2023). They felt that if an unprecedented, large-scale anti-SUD foodware regulation were to be tested anywhere, the highest likelihood of adoption was in a city known for being the bellwether of environmental activism in the U.S.

Over the years, members of the coalition saw the successes of the anti-expanded polystyrene and anti-SUD plastic bag regulation through reduced prevalence of both items (City of Berkeley, 2019a; Hahn, 2018). The anti-SUDs norm was therefore already established in the city. However, the coalition noticed that both regulations fostered the use of alternative SUD materials: for expanded polystyrene, that meant more SUD polyethylene terephthalate (PET) cups and food containers, for SUD plastic bags, that meant more SUD paper bags. The coalition did not want a regulation that prompted the use of a different SUD material, it wanted the reduction – and ideally elimination – of SUD materials. It therefore focused on promoting reusable foodware (Ecology Center, 2023).

⁶ The Ecology Center is not only one of the city's recycling service providers but also manages curbside composting, has a zero waste store and seed library, oversees the city's farmers markets and statewide nutrition assistance benefits program at farmers markets, and conducts community education and outreach events

To create the anti-SUD regulation, the coalition met with Councilmember Sophie Hahn who positioned her election campaign on environmentalism. The aim of this collaboration was to gain her as the government representative norm entrepreneur: have her embody and promote regulation that aligned with the anti-SUD foodware norm. Pragmatically, that initially entailed the coalition to better understand the potential pushback, needed regulatory components, and proper processes to develop and pass a regulation that they hoped would become a ‘model ordinance’ for other jurisdictions to adopt.

In the interviews, coalition members mentioned anticipated pushback from the plastics industry (producers) and large food chains (food businesses) because of the divestment in products and added operational expenses, respectively. Neither anticipated pushback gained substantial ground. This is potentially because 1) Berkeley has few large food chains after a decades-long permitting prioritization of small, locally owned businesses; 2) no individual can donate more than \$250 to an election campaign, meaning wealthier residents do not have an outsized relationships with government; 3) the coalition met with food business managers and owners to better understand their concerns and adjusted the ordinance accordingly; 4) Councilmember Hahn met with a few food business owners to influence her revisions to the regulation; and 5) while Berkeley might be a bellwether of environmental activism, it is still a relatively small city so such policies do not necessarily pose a threat to the plastics industry or large food chains (Ecology Center, 2023). Without the unanticipated pushback, the anti-SUDs norm-to-policy process made progress early on.

Then, however, there were two large unanticipated pushbacks: from the disability justice community (activist organizations) and from some local food businesses (Ecology Center, 2023). In the late 2010s, there was a California- and nation-wide movement gaining momentum: the removal of SUD plastic straws from cafes and restaurants. The anti-SUD plastic straw campaign proliferated through grassroots, social media-based campaigns centering the video of a turtle harmed from a plastic straw stuck in its nostril (Mosquera, 2019). This launched campaigns such as #mylaststraw that shamed consumers and food businesses from accepting or providing SUD plastic straws (Adell, 2020). The disability justice community coalesced in response, opposing these restrictions because straws are a needed tool for them to consume and not providing straws, providing them for a fee, or requiring individuals to request them further marginalizes individuals and accentuates accessibility disparities (Kessler, 2019). As for the other unanticipated pushback – from some local food businesses – in 2018 Berkeley adopted a new minimum wage of \$15, meaning all employees, regardless of their position, must earn at least \$15 an hour if they work more than two hours in one calendar week. According to an interviewee, the added costs associated with the anti-SUD foodware ordinance seemed prohibitive in combination with the increased labor costs.

These unanticipated pushbacks stalled the progress of the ordinance’s development. The coalition and Councilmember Hahn slightly adjusted course by meeting with individuals and representatives specifically on these topics (City of Berkeley, 2019a). The policy was revised to allow SUD plastic straws on a request-only basis (versus being provided automatically) and hardship waivers and technical assistance grants were included to give food businesses two extra years to comply with regulations and up to \$500 to purchase reusable dishware, a dishwasher, or any other one-time compliance-based purchases (Hahn, 2018). Further, to ease transition difficulties and constraints, the policy included a three-phase approach, meaning different components of the policy were implemented

across three time periods and they were not enforced until one year after each component was enacted (City of Berkeley, 2019b).

The ordinance, as a single policy, has numerous mechanisms, making it uniquely comprehensive. The three phases of the policy are 1) all food businesses with bussing stations must have all three waste bins (compost, recycling, landfill) accessible to the customer, plus the City or any City-sponsored event must purchase BPI-certified compostable foodware; 2) all food businesses must only provide BPI-certified compostable foodware, all food businesses must put a \$0.25 charge on all SUD cups, all food businesses must display the SUD cup charge on individual menus, menu boards, ordering platforms, and receipts, as well as verbally inform if order is placed over the phone; and 3) all food and beverage orders consumed on-site must be in reusable foodware. In total, the policy includes five creative and two destructive mechanisms (see Table 2.2).

Policy Mix	Analysis of the Policy Mechanisms of Berkeley’s Single Use Foodware and Litter Reduction Ordinance
<i>Creative</i>	
Knowledge creation, development and diffusion (C1)	YES - The City must create and maintain a list of acceptable SUD foodware types on its website.
Establishing market niches/market formation (C2)	YES - public procurement, labelling
Price-performance improvements (C3)	NO - while there are grants to support the transition toward compliance, and one local nonprofit funded a pilot of a reusable beverage service, no funding came from the City to support R&D to make innovations price-comparative with incumbent technologies
Entrepreneurial experimentation (C4)	YES - reduced uncertainties for testing bio-based SUD beverage and food containers by providing a market with such purchasing requirements
Resource mobilization (C5)	NO - there are no resource mobilization components in the policy; however, in conjunction with the policy, technical assistance grants are available to food businesses for up to \$\$ to support their transition to compliance
Support from powerful groups/legitimation (C6)	YES - public procurement, labelling; required compliance from large food businesses thus signaling the ability to transition to smaller food businesses and other businesses in other locations
Influence on the direction of search (C7)	YES - voluntary agreements and goals; while not directly outlined in the ordinance (these either predated the ordinance or happened concurrently), the ordinance helps realize such agreements and goals
<i>Destruction</i>	
Control policies (D1)	YES - the ordinance has both a ban (on fossil fuel-based plastics) and a fee (on SUD cups); there is also a ban on all SUD foodware items for on-site dining

Significant changes in regime rules (D2)	YES - all food businesses that have a bussing station for customers to self-bus their waste must have all three waste bins (compost, recycling, landfill); all SUD foodware accessories must be provided by request only or at a self-serve station
Reduced support for dominant regime technologies (D3)	NO - the ordinance does not change the preexisting support for incumbent technologies (fossil fuel-based plastic)
Changes in social networks, replacement of key actors (D4)	NO - the ordinance does not influence the social network, replace key actors, or form new organizations or networks

Table 2.2: A policy mix analysis of Berkeley's Single Use Foodware and Litter Reduction ordinance.

The Berkeley ordinance was unanimously approved by all nine City Councilmembers (including the City's mayor) on January 22nd, 2019. Phase one went into effect immediately. Phase two went into effect on January 1st, 2020, then phase three was supposed to go into effect on July 1st, 2020. In March 2020, the City of Berkeley declared a public health emergency due to COVID-19, which included a stay-at-home mandate. Food and beverages were only allowed for take-out and delivery, customers' personal mugs were not accepted at food businesses, and while in 2019 a local nonprofit initiated a reusable cup pilot program in the absence of a city sponsored program, that shut down. This meant all orders from food businesses were in SUD foodware items. The city triaged its personnel and budget to support COVID-19 and while the ordinance was never official paused, it no longer received personnel, budget, or resources.

5.2 What's Next for Berkeley and the Anti-SUD Foodware Norm Emergence?

The nonlinearity and unanticipated support and pushback from stakeholders in codifying the Berkeley ordinance exemplifies such tendencies across the entire anti-SUD foodware norm emergence. Pre ordinance, Berkeley, California, would have been considered fertile grounds for such environmentally progressive legislation. Yet, the policy required years of stakeholder engagement and numerous iterations of the policy's language; it bred conflict between heterogeneous priorities and values, and still produced a policy that stalled in implementation due to the weakening of the anti-SUD foodware norm in association with COVID-19 (Heiges & O'Neill, 2020; Heiges, Iles et al., n.d.). The Berkeley ordinance was illustrative of the difficulties in codifying emerging norms.

The Berkeley anti-SUD foodware policy is just one policy amid the larger anti-SUDs norm emergence, however, it gives important insight into the larger anti-SUD foodware norm emergence. It demonstrates the strengths and weaknesses of a multi-mechanism policy approach and the context in which it can be developed. The Berkeley ordinance's strengths are that it had a robust team of norm entrepreneurs and that it has numerous policy mechanisms that are both creative and destructive. Furthermore, the norm entrepreneurs – the coalition – went to great lengths to preempt pushback by conducting substantial community involvement initiatives and policy co-development. The norm entrepreneurs also aptly managed unanticipated pushback. The Berkeley ordinance came with significant press, where it was positively featured on major industry and public news outlets (Karidis, 2019; Los Angeles Times Editorial Board, 2019), and a reference point for zero waste practitioners (CalRecycle, 2023; U.S. EPA, 2022b; Upstream, 2023). That press likely contributed to the anti-SUD

foodware social imaginary: it gave a clear vision and goal of what type of anti-SUD foodware policy mechanisms were possible to pass at the local level.

The above case focuses on the creation and passing of the Berkeley ordinance, and since its passing four years ago, it is clear that there are a few weaknesses to the structure of the policy. One way to quantify a policy's structural strength is through policy intensity (Schmidt & Sewerin, 2019), which is not an analysis framework currently integrated into the policy mix framework or norm emergence theory. The Berkeley ordinance's intensity is minimal: there was a lack of framework; while budget was allocated, it was not executed; implementation ceased with the onset of COVID-19; and there was no enforcement (Heiges, Iles et al., n.d.). The shortfall of the policy's intensity undermines the robustness of the policy's multi-mechanism balance because without a stronger policy intensity, the policy has effectively not been enacted. Increasing the Berkeley ordinance's policy intensity as well as the intensity of any future policies based on it, will strengthen the progression and resiliency the anti-SUD foodware norm emergence.

The anti-SUD foodware norm emergence is in the cascade phase, but there must be more policies if it is to reach norm internalization. The Berkeley ordinance helped propel the anti-SUD foodware norm codification, and continues to gain nationwide attention plus be the basis for other anti-SUD foodware policies (Ecology Center, 2023; Upstream, 2022b). Since the Berkeley ordinance was adopted in January 2019, 17 cities across the U.S. adopted similar policies (Upstream, 2022b). Some of those policies are slightly altered, where supermarkets are required to display, sell, or receive refillable beverage containers; or instead of charging \$0.25 for a SUD cup, food businesses provide a discount for reusable cups. They all directly or indirectly manifested from Berkeley's policy: through policy development based on conversations with the Berkeley coalition or through leveraging the ordinance language and other resources. Further, all previously paused local anti-SUD foodware policies due to COVID-19 have resumed and all previously delayed policies are either implemented or being introduced (Upstream, 2022b). Additionally, a few states have enacted anti-SUD foodware policy, including unprecedented EPR instruments for this sector (Heiges & O'Neill, 2021). The federal government is considering a few plastics reduction policies, such as public purchasing agreements, mandatory recycled content minimums, and infrastructure grants (Quinn & Rosengren, 2022).

Outside of the U.S., there are many anti-SUD foodware policies introduced or enacted (Karasik et al., 2022b; Upstream, 2022b). Most notably there is the European Union's Directive 2019/904 (The European Parliament and the Council of the European Union, 2019). It is part of, but also separate from, the anti-SUD foodware norm emergence because it does not focus exclusively on SUD foodware – though those are the majority of items covered – and it only focuses on plastic – which is just one of the SUD foodware materials. It is notable because it is a regional Directive, with 27 Member States. The case study for this study was a local policy because such action is exceedingly difficult in the U.S. at a level above the County; however, the European Union successfully passed a regional Directive in the same year Berkeley's ordinance was enacted. Further, the Directive places material restrictions on the Member States, through upstream and downstream reduction methods, such as EPR, design requirements, bans, and collection infrastructure. This, like the Berkeley ordinance, is a multi-mechanism policy approach to both aid niche-innovations and erode unsustainable incumbents. The Directive has not been thoroughly researched through the policy mix framework or the norm emergence theory so it is difficult to further compare the two.

At the global level, the United Nations General Assembly began negotiations in late 2022 to create the Global Plastics Treaty, including consideration for a full lifecycle approach, which examines the harms generated from product design to disposal to better inform strategies and policies for plastic and pollution reduction (UN Environment Programme, 2022). This step toward globalized policy codification is another indication of the cascading anti-SUD foodware norm.

5.3 Future Research

I recommend future research in three arenas: anti-SUD foodware norm emergence, the policy mix framework, and the norm emergence theory.

For the anti-SUD foodware norm emergence, with the rise of policies with numerous mechanisms, it will be important to better understand the critical components and how they can harden to future macro-level disruptions (e.g., pandemic, change of political leadership). Further, it is essential to understand if it is more effective in reducing SUD foodware waste to base policies on multiple foodware items (versus a singular item which was done in the past) and on multiple material types (versus a singular material item which is still common).

The policy mix framework is valuable in analyzing a suite of policies, but more cumbersome in analyzing a specific policy, as indicative in the analysis of Berkeley's ordinance. Each of the eleven categories are quite broad with numerous mechanisms within it. Those mechanisms can vary in their scope and some policies contain numerous mechanisms within one category or multiple categories. The representation of one mechanism in one category is therefore not necessarily comparable to another policy with that same category represented. To better compare between policies and to better analyze the strengths and gaps within one policy, it is imperative that the policy mix framework adopts a weighting system to refine comparisons and analyses. I recommend integrating the policy intensity (Schmidt & Sewerin, 2019) framework to assess the structural integrity of the policy and applying a weighting system by coding questions, values, aggregated value, and range (Schaffrin et al., 2015).

Finally, for the norm emergence theory, more research is needed to assess the resilience of a norm during the different phases of its emergence. Greater evaluation of the aspects that foster or erode resilience could help inform development pathways regarding which policies to support. Resiliency also includes scalability because for norms to cascade and internalize, scale is needed. It is therefore critical to review if the challenges – such as producer and interest group pushback – are fundamentally different across scales to strategize for heightened resiliency. Finally, examining, and potentially quantifying, resilience might also help define the ambiguous phases of norm cascade and internalization, thus contextualizing the development of the norm and its available opportunities.

6. Conclusion

SUD foodware are undergoing a policy-based sustainability transition that encompasses formal and informal policies, and is thereby better categorized as an emerging norm: the anti-SUD foodware norm. The three phases of a norm emergence are norm entrepreneurs, norm cascade, and norm internalization. Historically the norm emergence theory has failed to quantitatively capture when an emerging norm is in one phase versus another. I therefore proposed, and applied, the policy mix framework to the theory to provide that means of phase quantification. I first applied the framework with the various anti-SUD foodware policies in the U.S. Then I validated this approach by applying the

framework to a specific policy in the U.S.: Berkeley, California's Single Use Foodware and Litter Reduction ordinance.

The disparate, non-linear adoption of anti-SUD foodware policies spans myriad SUD materials and items, from the local to global level. It is essential to coalesce them under one umbrella – SUD foodware – to increase understanding, research, and action, and thus progress, toward a waste-free future. The proliferation of anti-SUD foodware policies in the U.S. range from creative policies (supporting anti-SUD foodware innovations) to destructive policies (eroding SUD foodware incumbents). By coalescing these policies and by analyzing them through the policy mix framework, I demonstrate that the anti-SUD foodware norm is in the cascade phase and that the norm can be strengthened to progress toward norm internalization.

Chapter 3

Reaching for a Sustainability Transition in Berkeley, CA: Evaluating the Effectiveness of an Anti-Single Use Disposable Foodware Policy

This chapter was included here with permission from co-authors

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Abstract

Single use disposable (SUD) foodware is an increasingly large waste and litter problem in the U.S. One strategy to combat this rising harm is through targeted policy mechanisms. Over the years, local and state jurisdictions have implemented anti-SUD foodware policies, mostly aimed at banning or charging extra for the specific material and/or foodware item. In 2019, Berkeley, California passed its most comprehensive anti-SUD foodware policy to date, featuring numerous policy mechanisms to reduce SUD foodware and to foster alternative, more sustainable practices, aiming to be a model for other jurisdictions to follow. Over four years (2019-2022), we collected observational survey data based on the policy's mechanisms, to assess prepared food vendor's compliance with the policy, and thus effectiveness of the policy. COVID-19 occurred in the second year of this study and the shelter-in-place mandates enacted in Berkeley greatly impacted vendor operations and the City's budget, resources, and personnel. During the entire study period 83% of the policy mechanisms had only a minimal rise in compliance by prepared food vendors. The COVID-19 lockdown slowed adoption and implementation of the Ordinance and our data reflects this. However, we find independent factors impacted the overall effectiveness of this novel and expansive policy, before and after the lockdown. Current efforts to invigorate implementation across civic and community actors provide insights into how other cities might approach this phase of the public policy cycle. The article ends with a few recommendations to alter the policy and actions the City can take to increase vendor compliance with, and thus effectiveness of, the policy.

1. Introduction

In the U.S., single use disposable (SUD) foodware (e.g., plates, cutlery, bags, napkins, cups, straws) make up roughly 30% of all waste produced (U.S. EPA, 2015). In urban settings SUD foodware comprise 67% of the litter (Jaeger, 2011). The U.S. is consuming SUDs at unprecedented rates (Jambeck et al., 2015) and it is estimated that 85% of the plastic SUDs ever created, or 66,680 metric tons, is still in existence as of 2017 (Geyer et al., 2017).

To combat this proliferating waste, jurisdictions across the world have rapidly enacted anti-SUD foodware policies (Heiges, n.d.; Upstream, 2022b). In the U.S., this policy movement began by reducing plastic SUD foodware, item by item: SUD plastic bags (Clapp & Swanston, 2009), SUD plastic water bottles (Lee, 2010), then plastic straws (Schnurr et al., 2018). Eventually policy was adopted to reduce all plastic SUDs (Shipton & Dauvergne, 2022). Now, this policy-based sustainability transition to a SUD foodware-free system is focused on reducing all SUD foodware items of any material type. The policy mechanisms to effect such change are nascent and their effectiveness is uncertain, especially since there is a large gap in peer-reviewed studies on the matter (Diana et. al, 2022). That uncertainty in effectiveness, however, is not preventing jurisdictions from adopting such mechanisms. In fact, one city unprecedentedly adopted numerous anti-SUD foodware policy mechanisms with the intent of taking a

more comprehensive strategy towards reducing SUD foodware. In January 2019, that city, Berkeley, California, unanimously approved the *Single Use Foodware and Litter Reduction Ordinance*, henceforth the “Ordinance.”

This study therefore aims to thoroughly assess that unprecedented policy, especially as a key contributor to the policy-based anti-SUD foodware sustainability transition and amid the gap in research on such policy effectiveness. This study is therefore the first assessment of a ‘model ordinance’ (a multi-mechanism policy for other jurisdictions to adopt) through a longitudinal mixed method approach. Berkeley is historically a bellwether when it comes to waste reduction efforts, including originating curbside recycling in 1973, banning polystyrene in 1990, and adopting one of the strictest bans on SUD plastic bags, including a ban on ‘pre-checkout’ (e.g., produce) bags in 2023 (Ecology Center, n.d.; Harrison & Hahn, 2022; Skinner, 1988). Meaning, there is precedence of Berkeley adopting a new sustainability policy or practice that proliferates across the country. It is therefore important to assess what occurs in Berkeley knowing that while the city’s conditions are unique, policy actions might be replicated elsewhere. Additionally, and unintentionally, this study provides rare insight into SUD foodware conditions before, during, and immediately after COVID-19 lockdowns. So, while the research questions are focused on the policy’s effectiveness, it is also a study of COVID-19 lockdown implications on SUD and reusable foodware.

Policy is a key component to sustainability transitions (Kivimaa & Kern, 2016; Köhler et al., 2019). This is especially true for transitions that focus on “wicked problems,” which are the highly complex problems that do not have a single or quick solution, involve numerous stakeholders, span multiple disciplines, encompass large geographical scales, and take years to initiate and implement (Rittel & Webber, 1973). The food-energy-water system (FEWS) is one such wicked problem (Bird et al., 2022), and anti-SUD foodware policies reside in that wickedness. In such complexity, policy is not the only solution mechanism, but it is an important one, and maybe even an essential one (Heiges, n.d.). To better understand the contributions of policy in a sustainability transition, it is key to identify policy priorities, stakeholder engagement, and mechanisms used (Porter & Ashcraft, 2020; Rosenbloom et al., 2020). The Ecology Center, a nonprofit in Berkeley, California dedicated to improving the health and environment of the city’s residents, developed a ‘Disposable Free Berkeley’ toolkit to identify some of those components as they pertain to how the Ordinance was developed: who the stakeholders were, what the community input process was like, what was anticipated and unanticipated pushback, and how to create a policy that was unanimously passed by City Council (Ecology Center, 2023). This study goes further, not only by creating an experiment to remove impacts of confounding variables and increase potential for generalizability. This study also addresses if an unprecedented policy – one that is intended to be adopted by other jurisdictions as part of the emerging norm that is the policy-based anti-SUDs foodware sustainability transition – is effective in obtaining its objectives. Furthermore, this study begins analysis on the economically contentious aspects of sustainability transition policy (STP). Such ‘green economy’ or ‘sustainable finance’ analyses are rare (Gibbs & O’neill, 2016; Ryszawska, 2016), thus essential as a means to better understand the associative harms and opportunities. So, this research provides unparalleled insight into policy effectiveness and begins discussion on key STP components such as equitable financial structures, the balance of policy mechanisms, and the types of niche-innovations to foster. It also is the first publication of a validated quantitative observational survey and methodology, thus providing a standardized data collection and analysis process for anti-SUD foodware policy evaluation in other jurisdictions. We hope that helps further the field for such necessary evaluative tactics and thus anti-SUD foodware policy adoption and embeddedness.

This study provides numerous key STP insights. First, it demonstrates that the inclusion of multiple policy mechanisms can provide a more comprehensive system transition, knowing that the

mechanisms will have different compliance rates and foster waste reduction in different ways. The second is how a weaker policy structure – especially for budget, implementation, and monitoring – does not necessarily promote greater compliance with the policy. Additionally, this study demonstrates the importance of fostering multiple niche-innovations to increase the effectiveness of a policy and likelihood of a sustainability transition. Further, this study provides insight into how prepared food vendors (e.g., restaurants, cafes, grocery stores) were disrupted during COVID-19, including their ability to, or prioritization of, policy mechanisms they could comply with due to operational constraints. Finally, it also showed that amid the COVID-19 disruptions, vendor compliance with the policy did increase – though minimally – over the four years, so it is possible to introduce anti-SUD foodware policy at the local level and realize progress, even during a global pandemic.

1.1. The Case Study and Research Questions

The City of Berkeley’s Ordinance was structured in three phases to progressively decrease SUD foodware consumption, landfill disposal, and litter in the city. To ease the transition to compliance, each phase was set for enactment, then enforcement one year later. The three phases were 1) immediately upon the passing of the Ordinance, all City-owned facilities and City-hosted events must only provide compostable foodware certified by the Biodegradable Products Institute (BPI), and all prepared food vendors (henceforth ‘vendors’) that have a bussing station for customers to dispose of their waste must have all three color-coded receptacles (compost, recycling, landfill) available and with signage, and all SUD foodware accessories (e.g., cutlery, straws) must be provided by request only or at a self-serve station; 2) if vendors provide SUD foodware, it must be certified compostable, and all SUD cups must have a \$0.25 charge on them that is clearly marked pre-sale (e.g., on menus) and post-sale (e.g., receipts); and 3) all vendor meals and beverages consumed on-site must be consumed in reusable foodware. A few additional components of the Ordinance include food vendors removing the SUDs cup charge if a customer brings their own cup; that all food vendors must have a supply of SUD plastic straws behind the counter so if a customer requests one for any reason, including having a disability, they may receive one; hardship waivers for food vendors to apply for if compliance is financially unviable; and that food vendors remove the SUD cup charge for a customer if they have a payment card or voucher issued by the California Special Supplemental Food Program for Women, Infants, and Children (WIC) or an electronic benefit transfer card (EBT) (City of Berkeley, 2019b). Additionally, the City Manager was charged with, among other things, providing a list of acceptable SUD foodware materials and items, launching a reusable food container pilot, and reevaluating the Ordinance within three years (City of Berkeley, 2019a).

The objective of the Ordinance is to reduce the amount of SUD foodware that is landfilled or improperly disposed of (e.g., littering) in Berkeley, California. Constituent compliance with an environmental policy is the first step in assessing a policy’s effectiveness as it elucidates the strengths and weaknesses of the policy (Wilson et al., 2012). According to scholars of STP, if there is no compliance with the policy, then it is likely that it had an unsuitable policy mechanism(s) (Kivimaa & Kern, 2016), it was not structured well (Schaffrin et al., 2015), or it focused on the wrong solution (Schmidt & Sewerin, 2019).

The first factor determining effectiveness in STP is ‘policy mix’, an assessment of the suitability of the policy mechanism(s). Typically, anti-SUD foodware policy mechanisms aim to curb the demand for SUD foodware items (“destructive,” or destabilizing policies such as bans, taxes, and fees) but do not necessarily promote the advancement of alternative materials and systems (“creative policies” such as grants) (Heiges, n.d.; Kivimaa & Kern, 2016). Together, the four destructive policies and seven creative policies are known as the policy mix. Having greater policy coverage across the eleven policies is thought

to create a more holistic policy strategy, and thus a more effective and resilient sustainability transition (Kivimaa & Kern, 2016; Köhler et al., 2019). The Ordinance was unprecedented in that it was an anti-SUD foodware policy with multiple policy mechanisms; however, it arguably has too many destructive mechanisms.

An entire policy, even if it is composed of many types of mechanisms, can be evaluated on its effectiveness by how it is structured, which is known in STP as policy intensity. The theory is that the more structured the policy, the higher likelihood it will result in the desired policy output (Schaffrin et al., 2015). There are six measures within policy intensity to determine the level of structural strength: objective, scope, integration, budget, implementation, and monitoring. Each measure can be coded, resulting in a quantitative and thus comparable score. A higher score equates to a more structured policy. The Ordinance has a clear objective, scope, and integration; however, to date it arguably has fallen short on budget, implementation, and monitoring.

The third factor determining effectiveness of a STP is technology specificity. Developed in the renewable energy space, the measure originally focused on the technology(ies) established by a given policy. Here, we translate the concept to other niche-innovations like business models. The theory is that there must be sufficient policy to establish a certain niche-innovation, and that more than one niche-innovation should be established to increase the effectiveness of a STP (Rosenbloom et al., 2020; Schmidt & Sewerin, 2019). The Ordinance focuses on fostering three niche-innovations: reusable foodware, alternative materials, and waste reduction. However, the Ordinance is arguably too reliant on reusable foodware as a niche-innovation to reduce SUD foodware that is landfilled or improperly disposed of.

The Ordinance, therefore, might be overweighted on destructive policies, have insufficient policy intensity, and be too reliant on innovative reusable foodware systems. We designed a study to analyze those hypotheses because of the importance and potential influence of this policy. The Ordinance has been internationally touted as a potential model ordinance for other jurisdictions to adopt (Li, 2019), and some jurisdictions have already adopted many of its components (Upstream, 2022b). However, outside of a non-binding referral to the City Manager from Councilmembers, no one was planning to evaluate its effectiveness before such adoption. That trend of policy adoption pre validation has precedence. In California, jurisdictions adopted SUD plastic bag bans not because they were more effective than other mechanisms, but because jurisdictions had already adopted them (Wagner, 2017). Studying this unprecedented policy could therefore result in the identification of suitable (or unsuitable) mechanisms, strong policy structures, and appropriate niche-innovations, thus informing any alterations to the Ordinance and subsequent adoption of a similar policy by other jurisdictions.

Since constituent compliance across those three measures is an indicator for policy effectiveness, we focused our study on the constituents most beholden to the Ordinance: vendors. In entering this study, we aimed to evaluate the effectiveness of the historic Ordinance with the position that it might be overweighted on destructive policies, have insufficient policy intensity, and be too reliant on innovative reusable foodware systems. Therefore, the objective of this study was to understand vendor compliance with the Ordinance to elucidate how suitable the policy's mechanisms are, how well it was structured, and if it focuses on the right solutions.

Based on the research objective to evaluate vendor compliance with the Ordinance to identify effectiveness across three policy measures, we developed three research questions. The research questions center on the first four years after the Ordinance's adoption. The research questions are:

- Research Question #1: What were the different rates of compliance with the Ordinance’s five policy mechanisms?
- Research Question #2: How did the policy’s intensity influence compliance rate?
- Research Question #3: Was there progress in greater adoption of the three niche-innovations over the four years?

2. Methodology

To address the three research questions, we developed a quantitative observational survey and conducted qualitative interviews. The survey questions were based on vendors’ compliance with the policy mechanisms in the three-phased Ordinance. Trained data collectors filled out the survey through observation to not influence the vendors’ practices. Six subject matter experts from different disciplines and perspectives reviewed the survey questions and structure before it was field tested. A member of this research team conducted the field test at two vendor sites outside of the sample group, then revised the survey for clarity, ease of data collection, and to ensure the data desired were the data captured.

The sample group of vendor sites surveyed was randomly selected. In early 2019 we received a list of all registered vendors from the City of Berkeley’s Department of Economic Development. We culled that list to only include vendors that were required to abide by the Ordinance. Next, we created seven strata of food vendors to acknowledge potential compliance nuances by vendor type. The strata were bakery, farmers market, food products store (grocery store, convenience store), food service establishment (café, restaurant), food truck, gas station, and theater. Then we randomly selected 150 vendors to achieve a 95% confidence interval within each of those strata. This approach provides internal and external validity for the generalization of the results across the city, as well as prevents biases in the results.

In addition to selecting and surveying vendor sites in Berkeley, we wanted to survey vendor sites in adjacent cities in Alameda County (Albany, Emeryville, and Oakland) to provide a control group of vendors’ SUDs and reusable foodware practices without the Ordinance. Of the randomly selected vendors in Berkeley that had at least one site in at least one of the three cities, we randomly selected amid those additional sites outside of Berkeley to ensure we had a representative sample.

We collected these survey data for four consecutive years (2019-2022), during the same one-month (November-December) time frame each year. For each round of data collection, we had between 15 and 40 data collectors. The data collectors were undergraduates from the University of California at Berkeley, Berkeley community members, and members of the research team. Each data collector participated in a training prior to entering the field. For their participation, they received course credit and/ or a small stipend per vendor site visited to cover their survey cost. The survey cost was the purchase of a beverage item at the vendor site.

Data collectors visited the vendor site in the morning/ afternoon, afternoon/ evening, or anytime of the day based on the vendor’s hours of operation. We intentionally did not dictate the specific hour of day or day of week to visit to eliminate any temporal confounding variables. Once at a vendor site, data collectors ordered a beverage to gain insight into the SUD foodware operations as they related to the Ordinance, such as what foodware accessories are provided automatically with an order and if the SUD cup charge is itemized on the receipt. They also captured related items, such as if the employee asked if the beverage is “for here or takeout” and if there are any discounts on customers bringing their own reusable cup. The entire survey is in the Supplemental Material, Table S3.1.

Originally, the survey methodology included an observational tallying of the number of beverages purchased at a given vendor site during a 30-minute period. That component of the survey was removed after the baseline collection round in 2019 due to COVID-19 restrictions for on-site food and beverage consumption at vendor sites; in 2020 and 2021, it was not guaranteed that data collectors could remain on-site to gather that information.

Each vendor site was surveyed by one data collector each year. Vendor sites were not included in subsequent years if they closed or if their site location changed. If the vendor site reopened, then it was surveyed the following year(s). We did not survey a vendor site if the site changed because there are too many confounding variables associated with such a move (e.g., at the new site, the vendor does or does not have a dishwasher, there is or is not space for waste receptacles, and its patrons are more or less vocal on sustainability matters).

We did not include a methodology for data collection of food and beverage orders obtained through delivery, either directly from a vendor or from a third-party (e.g., Doordash). We omitted this because our research focus was on vendor-based compliance and the incorporation of a third-party delivery service made it too difficult to collect uncompromised data for any meaningful insight.

At the start of the study, we planned annual qualitative interviews of vendors to supplement the quantitative compliance data. These interviews, however, were exceedingly hard to obtain. We therefore only interviewed three vendors. These interviews included semi-structured, open-ended questions, focused on the policy mechanisms of the Ordinance and how they impacted the vendor. We also interviewed four people who were directly associated with the Ordinance or a similar ordinance in a different California jurisdiction. These 'expert' interviews included semi-structured, open-ended questions, focused on the similarities and differences between the policies, including the successes and hurdles in their implementation.

The vendor interviews were conducted between May and June in 2021. Each interview lasted between 30 and 60 minutes. Each interviewee held a management role for a vendor in Berkeley, with two being local vendors and one being a nationwide vendor. Two of the vendors were also part of the randomly selected quantitative observational survey group. None of the vendor interviewees were informed of the quantitative observational survey portion of the study. The expert interviews were conducted between November 2022 and February 2023. Each interview lasted between 30 and 60 minutes, and each was aware of the quantitative observational survey portion of the study.

This data collection and analysis methodology is not intended for causal relation, and instead provides correlational relation.

3. Results

The results for this analysis are Berkeley-specific and pertain only to vendors surveyed in Berkeley. We do not include results on the control group here because it is outside of the scope for this study. The number of vendor sites surveyed over the four years was 157, 125, 124, and 124 (in 2019, 2020, 2021, and 2022, respectively). During that time, on average, food service establishments represented 81% of registered vendors, food product stores represented 8%, and the remaining 11% were bakeries, farmers' markets, food trucks, gas stations, and theaters.

Important contextual information is that after the first (baseline) round of data were collected in 2019, COVID-19 hit. On March 4th, 2020, California Governor Gavin Newsom declared a state of emergency for COVID-19 (Office of Governor Gavin Newsom, 2022). On March 16th, 2020, Alameda County, which Berkeley is in, issued a shelter-in-place order for all non-essential activities (Lyons, 2020).

Then on March 19th, 2020, Governor Newsom issued a shelter-in-place order for the entire state (Office of Governor Gavin Newsom, 2020).

3.1. Policy Mix

Phase 1

The first phase of the Ordinance required a vendor with a bussing station to have all three waste receptacles (compost, recycling, and landfill) with signage (Section 11.64.080). Of the vendors that had a bussing station (and therefore needed the three waste receptacles and signage), the rates were 89%, 66%, 81%, and 82% over the four years. The percent of the vendors with bussing stations that were fully compliant with the waste receptacle mechanism was 19%, 16%, 23%, and 25% across the four years.

The first phase of the Ordinance also required SUD accessory foodware items (e.g., napkins, lids, straws, utensils) to be provided by request or at a self-serve station, not automatically (Section 11.64.030). The rates of compliance by vendors varied by accessory type and are shown in Table 3.1, over the four years. The percent of vendors that complied with the accessory mechanism increased from 2019 to 2022 for all recorded accessory types except any bag type (decreased from 47.1% to 37.9%) and multiple drink holders (remained relatively flat at 18.5% and 17.7%). Napkins, sugar/condiment packets, and utensils had the largest increase from 2019 to 2022, rising by 95%, 72%, and 60%, respectively.

SUD Accessory Foodware Item	2019	2020	2021	2022	% Change Between 2019 and 2022
Cold lids	26.8%	16.0%	31.5%	29.8%	12%
Hot lids	24.2%	17.6%	34.7%	31.5%	30%
Napkins	37.6%	53.6%	78.2%	73.4%	95%
Multiple drink holder	18.5%	12.8%	16.1%	17.7%	-4%
Utensils	29.3%	36.8%	58.1%	46.8%	60%
Straws	36.9%	30.4%	53.2%	47.6%	29%
Sleeve	21.0%	14.4%	31.5%	29.0%	38%
Sugars/ condiments packets	26.8%	36.0%	51.6%	46.0%	72%
Any bag type	47.1%	32.8%	37.1%	37.9%	-20%

Table 3.1: Percentage of prepared food vendors serving SUD accessory foodware items by request or at a self-serve station. This chart shows the percent of vendors surveyed in Berkeley that provided the specified SUD accessory foodware item by request or at a self-serve station over the four years of data collection. That approach is compliant with the Ordinance, with a higher rate meaning more vendors comply with regulatory parameters for that SUD accessory foodware item. The column on the far right shows the change in percent of vendors complying per that item between 2019 (baseline) and 2022 (final year of data collection). In that column, the colors convey the difference in percent of vendors complying over the four years. Orange means there were a decrease in vendors that complied (<0%), yellow means there was a moderate increase in vendors that complied (0-40%), and green means that there was a large increase in vendors that complied (>40%).

In conjunction with the two mechanisms in the first phase, we captured if employees asked customers if their order was “for here or takeout”. In 2019, 79 (58%) of employees asked about a customer’s order. In 2020 that plummeted to 3 (5%) employees, then in 2021 the number rebounded to 37 (42%), and remained flat in 2022 at 38 (40%). If a vendor did not have on-site dining, they were removed from this specific analysis as all orders were takeout.

Phase 2

There are two mechanisms in the Ordinance’s second phase. The first pertains to the SUDs foodware material type, Disposable Foodware Standards (Section 11.64.070). All SUD foodware must be compostable in the City of Berkeley municipal compost collection programs and not contain any intentionally added fluorinated chemicals. The rate of vendors with compliant SUD cups increased each year: 25%, 28%, 30%, and 44%. The rate of vendors with compliant SUD foodware was more turbulent: 54%, 56%, 49%, and 48%.

Relatedly, food wrapper material (e.g., the tin foil around a burrito) must be either compostable or recyclable according to the City of Berkeley’s municipal collection programs. The percent of prepared food vendors with compliant food wrapper material increased from 30% to 80% between 2019 and 2022.

The second mechanism in the second phase was the adoption of a \$0.25 charge on each SUD cup provided, as well as mentioning the charge pre-sale (e.g., menus) and post-sale (receipt) (Section 11.64.050). In 2020, one vendor mentioned the charge pre- and post-sale, charged the fee, and accepted a customer’s reusable cup. That is full compliance. In 2021, there were three vendors in full compliance. In 2022, there were three vendors in full compliance. Each year there were vendors that had partial compliance because they either mentioned the charge pre- or post-sale, but not both. In 2020, three vendors were in partial compliance, in 2021, four vendors were in partial compliance, and in 2022, twelve vendors were in partial compliance.

Separate from, but related to, this mechanism is that customers may provide their own reusable cup for beverage service, however, the vendor has the right to refuse it (Section 11.64.040). The rate of vendors accepting a customer’s cup varied over the years, from 56% (2019), 12% (2020), 36% (2021), and 41% (2022), as shown in Figure 3.1.

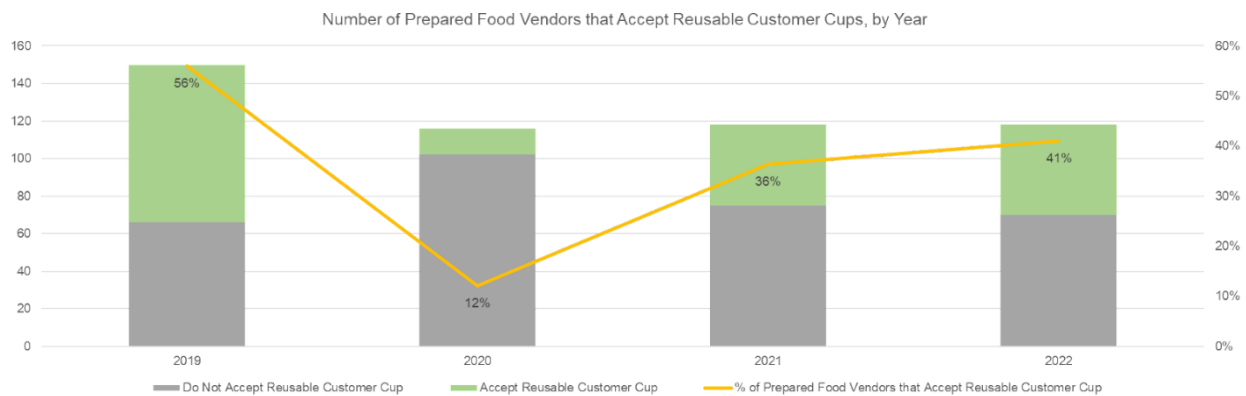


Figure 3.1: Over the four years of data collection, the rate of vendors accepting a customer’s cup fluctuated. It started at 56% in 2019, then dropped to 12% during the height of COVID-19 restrictions, and grew to 36% in 2020, then 41% in 2022.

Phase 3

The third phase of the Ordinance focused on reusable foodware (Section 11.64.060). The percent of compliant vendors with on-site dining and reusable cups went from 46% in 2019 to 61% in 2022. The percent of compliant vendors with on-site dining and reusable food containers went from 46% in 2019 to 48% in 2022.

Overall, as shown in Table 3.2, the Ordinance, from the perspective of the vendors, had two policies that were firmly creative, two that were partially creative, two that were firmly destructive, and one that was partially destructive.

Policy Mechanism Category	Examples of the Policy Mechanism	If the Ordinance’s Policy Mechanism Pertains to Vendor
Creative Policies		
Knowledge creation, development and diffusion (C1)	Educational; knowledge creation; data transparency; reference/ procurement guides	NO - Vendors must provide "written records evidencing compliance" if a City Manager or designated representative requests them, but those records are not publicly available or otherwise meant as a means of knowledge creation/ dissemination. Furthermore, there is no avenue to share learnings/ successes between vendors.
Establishing market niches/market formation (C2)	Market stimulation; economic policy instruments; public procurement	NO - Public procurement and labeling (the two market formation mechanisms in the Ordinance) only pertain to compliant SUD foodware materials (alternative materials) and do not support vendors.
Price-performance improvements (C3)	Subsidies for learning-by-doing; research and development (R&D) support	NO - While there are grants to support the transition towards compliance, and one local nonprofit funded a pilot of a reusable beverage service, no funding came from the City to support R&D to make innovations price-comparative with incumbent technologies
Entrepreneurial experimentation (C4)	Diversifying offerings and capabilities; financial investments	PARTIALLY - While authors of the Ordinance and City Councilmembers would like to foster reusable foodware innovation, there is limited budget and resources dedicated to such experimentation (in the form of technical assistance grants), thereby fostering limited stimulation of entrepreneurship and diversification of existing firms.
Resource mobilization (C5)	Deployment subsidies; low-interest loans; labor-market policies; secondment of expertise	<p>YES - The City offers waivers for non-compliance with either/both the SUD foodware material specifications (compostables) and/or providing reusable foodware for on-site dining. Vendors must apply for the waiver(s), demonstrate need for the waiver(s), and there is a term limit on the waiver(s).</p> <p>PARTIALLY - The City offered technical assistance grants to vendors to support their transition to compliance; however, that was not written into the policy and therefore does not abide by the truth of</p>

		this category (even if it does abide by the spirit of this category).
Support from powerful groups/legitimation (C6)	Innovation platforms; public procurement; labeling	NO - While there are numerous advocacy organizations and other jurisdictions that are adopting some or all components of the Ordinance, there is no formal or informal legitimization for vendor compliance to the innovations.
Influence on the direction of search (C7)	Non-binding goals and voluntary actions; targeted R&D funding schemes; tax incentives	PARTIALLY - This policy does not conflict with any stated vendor sustainability goals and in fact likely supports them. It also could influence the direction of search (if Berkeley is considered a large enough market to warrant vendor search and if there is enforcement to further support vendor search). However, there are no targeted R&D funding schemes, tax incentives, or other proactive attributes that support the direction of search.
Destructive Policies		
Control policies (D1)	Command-and-control; market-based; nudges; quantity limits; material requirements	YES - the ordinance has both a ban (on fossil fuel-based plastics) and a charge (on SUDs cups); there is also a ban on all SUDs foodware items for on-site dining
Significant changes in regime rules (D2)	Take-back; right-to-repair; shared responsibility; bring your own (BYO); pool system	YES - all vendors that have a bussing station for customers to self-bus their waste must have all three waste bins (compost, recycling, landfill); all SUDs foodware accessories must be provided by request only or at a self-serve station
Reduced support for dominant regime technologies (D3)	Withdrawal support for incumbent technologies	PARTIALLY - The Ordinance does change the preexisting support for incumbent technologies (SUD foodware) by banning such material; however, that change in support is more appropriately categorized under control policies (D1), because the Ordinance does not change the financial legislation for incumbent technologies (e.g., eliminate subsidies for fossil fuel companies).

Changes in social networks, replacement of key actors (D4)	Replacement of key actors	NO - The Ordinance does not influence the social network, replace key actors, or form new organizations or networks.
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Table 3.2: Berkeley’s Single Use Foodware and Litter Reduction ordinance mapped onto the policy mix framework. From the perspective of vendors, the above chart shows which types of policy mechanisms were, were not, or were partially represented in the Ordinance. The Ordinance had two policies that were firmly creative, two that were partially creative, two that were firmly destructive, and one that was partially destructive. There are seven possible creative policies and four possible destructive policies.

3.2. Policy Intensity

The COVID-19 orders resulted in the closure of almost all on-site dining and the reallocation of City budget, personnel, and resources to combat the spread of COVID-19. At no point was the Ordinance officially paused or rolled back; however, like the other City departments, all previously allocated budget, personnel, and resources were not deployed or were reallocated to support COVID-19 relief efforts, effectively pausing the Ordinance. Prior to the count, state, and federal health orders, the City of Berkeley’s Councilmembers had referred to the City Manager to “determine funding and staffing needs and sources of funds to implement each program/phase” (City of Berkeley, 2019a), which included collaboration between Department of Planning and Development, Office of Economic Development, and the Zero Waste Division. However, there were no formal roles assigned and published before COVID-19, and there were numerous vacancies in the Zero Waste Division, which was the designee expected to undertake the majority of the staffing tasks. Additionally, the two staff in the Zero Waste Division at the time were assigned as disaster service workers once COVID-19 began, and the City did not want to add the extra burden of vendor compliance on vendors who were among the populations hardest hit by the pandemic. Moreover, while the City Council referred the City Manager to set up technical assistance support and a mini-grant program for vendors to comply with Ordinance mechanisms (City of Berkeley, 2019a), neither of those were implemented before COVID-19 orders were announced or by the final round of data collection in late 2022. The waivers for vendors to submit if they could not comply with the Ordinance was launched before COVID-19 occurred (City of Berkeley, 2022); however, there was little announcement of that release and as of early 2023, no vendor had applied for a waiver.

Table 3.3 shows how we scored the Ordinance across the six measures of policy intensity, including the coding questions for evaluation, the possible score, the coding value description, and the coding value.

Intensity Measure	Coding Question	Possible Score	Coding Value Description	Coding Value
Objectives	What is the policy objective with respect to policy performance?	0-1	While no specific target is given (which is common), there was a generalized ambition that was transparent to all stakeholders to reduce SUD foodware that is landfilled or improperly disposed of.	0.75

Scope	<p>Does the policy include branches of both supply and demand side?</p> <p>Are all mitigation actions targeted?</p>	0-1	<p>The policy puts an overweighted burden on vendors for compliance. Incumbent SUD foodware producers have a lot to lose, which resulted in some bargaining/ lobbying; however, it was the vendors and disability justice group that objected the most to the initial policy proposal. Mitigation actions were targeted. There could be more economic burden mitigation actions for both the vendor and consumer. The breadth of potential winners is vast and spans economic, environmental, and social.</p>	0.75
Integration	<p>Is the policy mechanism integrated in a package or any reference to other policy mechanism?</p> <p>Is framework policy included?</p>	0, 0.5, 1	<p>The policy design intentionally aimed to not contradict or conflict with pre-existing policy action. As a policy package with multiple policy mechanisms, it increases its likelihood of obtaining the policy's objective. Framework policy is included.</p>	1
Budget	<p>What are the set expenditures/ impositions of the policy mechanism?</p>	0-1	<p>While the Mayor and a City Councilmember referred to Council the need for the City Manager to calculate staff time, costs, sources of funding, and community partnerships, this was never deployed. Set expenditures/impositions of the policy mechanism have therefore not been calculated and/or ear marked (which is common with model policy). The City is formalizing a partnership to provide technical assistance and financial support via mini-grants to cover one-time costs associated with conversion to reusable foodware. The score is low because while there are plans for such resources, they were not set and administered, in part because of the structure of the Ordinance, and in part because of COVID-19 restrictions. That is except for the waivers for vendors unable to comply with components of the Ordinance, which was released in 2019 and stayed available throughout COVID-19 orders.</p>	0.25

Implementation	<p>Is there a statement about implementation procedures specifically allocating actors and rules?</p> <p>How is this implementation planned and is there sanctioning?</p>	0, 0.25, 0.5, 0.75, 1	<p>There is no statement about implementation procedures specifically allocating actors and roles. The City Manager is a catch-all for the majority of City-lead items, but there is no specificity in the Ordinance of the when/ how/ who, which is common for model ordinances. The expectation was for the Department of Planning and Development, Office of Economic Development, and the Zero Waste Division to discuss roles and responsibilities. The only clearly planned implementation was that enforcement would occur one year after enactment and that it would be complaint-based. Vendors had an outsized role for implementation; however, there are no clear procedures or guidance on implementation actions for vendors.</p>	0.25
Monitoring	<p>Is there a specific monitoring process for the policy mechanism and by whom?</p>	0, 0.5, 1	<p>The Ordinance refers to the City Manager to prescribe, adopt, and enforce rules, which include written notice and citation of noncompliance. However, in a Supplemental Packet, there is a note that “[o]nce launched, staff time for administration and enforcement of the Ordinance will be limited” (City of Berkeley, 2019a, p.3) and that enforcement would be complaint-based. So, while monitoring was assigned, the City knew it was not adequately supported through budget and labor.</p>	0.5

Table 3.3: An evaluation of Berkeley’s Single Use Foodware and Litter Reduction ordinance’s policy intensity. This chart, based on the chart created by Schaffrin et al. (2015), evaluates the strength of the Ordinance’s structure, and thus potential effectiveness, across six measures: objective, scope, integration, budget, implementation, monitoring. The Ordinance has a relatively strong objective, scope, and integration, but lacks adequate budget, implementation, and monitoring.

3.3. Niche-Innovation Specificity

In the Ordinance, there are five mechanisms that aim to foster three niche-innovations.

The mechanism that aims to foster reusable foodware is that all on-site dining must be on reusable foodware. Additionally, while not a mechanism, all vendors can accept a customer’s reusable cup. The rate of compliance with the on-site dining mechanism for reusable cups was 46% (2019), 20%

(2020), 55% (2021), and 61% (2022), and for reusable food containers 46% (2019), 15% (2020), 38% (2021), and 48% (2022), as shown in Figures 3.2a and b.

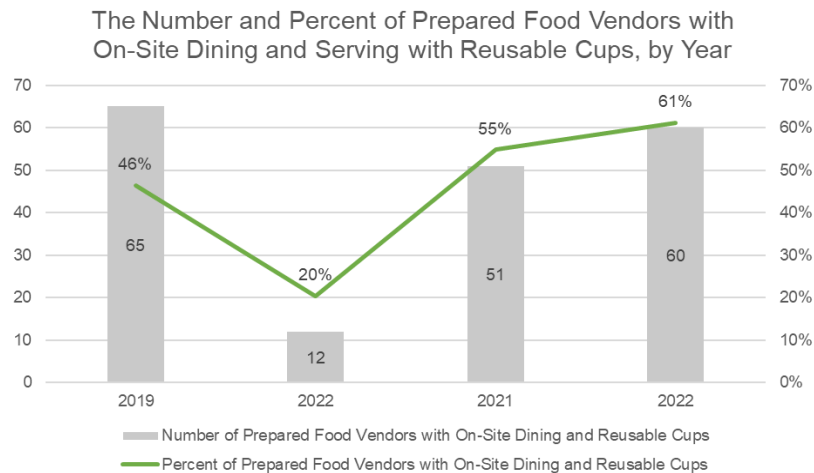


Figure 3.2a: The rate of vendors that complied with the on-site dining mechanism – to serve beverages in reusable cups – was 46% in 2019, 20% in 2020, 55% in 2021, and 61% in 2022. These rates only include vendors that had on-site dining available when data were collected.

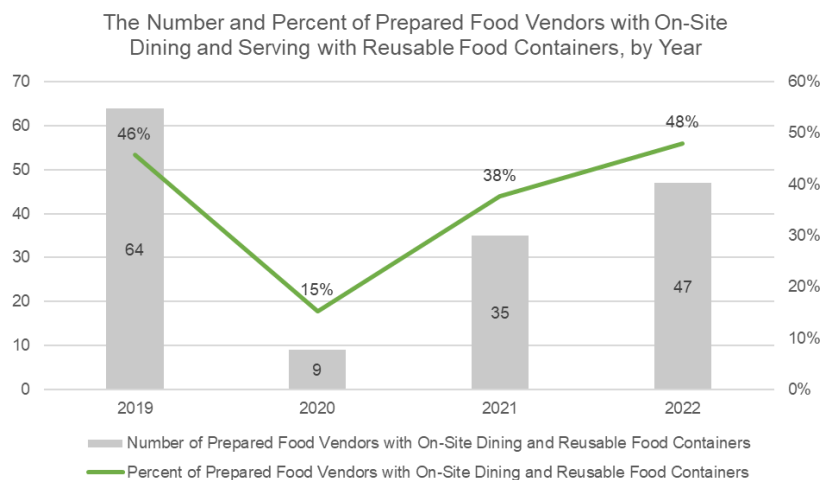


Figure 3.2b: The rate of vendors that complied with the on-site dining mechanism – to serve food in reusable food containers – was 46% in 2019, 15% in 2020, 38% in 2021, and 48% in 2022. These rates only include vendors that had on-site dining available when data were collected.

The two mechanisms that aim to foster alternative materials are that vendors must have all three waste receptacles and signage if they have a bussing station, and that all SUD foodware must be compostable in the City’s municipal compost program. The rate of compliance with the waste receptacle, signage, and bussing station mechanism was 19% (2019), 16% (2020), 23% (2021), and 25% (2022). The rate of compliance with the compostable SUD foodware material mechanism for SUD cups was 25% (2019), 28% (2020), 30% (2021), and 44% (2022), and for SUD food containers was 54% (2019), 56% (2020), 49% (2021), and 48% (2022).

The two mechanisms that aim to foster material reduction are that all SUD cups have a \$0.25 charge and that all foodware accessories must be provided at a self-serve station or by request only. The

rate of partial and full compliance with the \$0.25 charge mechanism was 0% (2019), 3% (2020), 6% (2021), and 16% (2022). The rate of compliance with the foodware accessories mechanism – an average across all accessory types – was 30% (2019), 28% (2020), 44% (2021), and 40% (2022).

4. Discussion

This longitudinal mixed method study is the first assessment of a multi-mechanism policy approach – one considered a ‘model ordinance’ for other jurisdictions to adopt – to reduce SUD foodware waste and litter. Below is a discussion of the results, which map to the three research questions, which in turn map to the three areas of measuring a STP’s effectiveness: policy mix, policy intensity, and niche-innovation specificity. All the data and thus results and discussion are positioned around the vendors’ compliance with the Ordinance.

Before discussing the results, however, it is important to provide context on the large influencing disruption that occurred after the first year of data collection: COVID-19. With COVID-19 came a flurry of governmental mandates and orders to curb the spread of the novel virus. Part of those declarations included the triage of City staff, resources, and budget to support COVID-19 relief efforts. Vendor sites temporarily or permanently closed, shifted almost entirely to takeout and delivery, and could not accept a customer’s cup or bag (Pan, 2020). Furthermore, different work types were categorized as essential meaning employees had to work even with heightened risk exposure (CDC, 2021b), there was the ‘great resignation’ from vendors because of poor working conditions (Chaturvedi et al., 2021), vendors cut staff because of costs (Riehle et al., 2021), there were global supply chain issues for vendors (Becker et al., 2020), and both vendors and customers feared surface-based virus transmission even after such contagion was disproved (Thompson, 2020). Zero waste and anti-SUD foodware policies were paused or not enforced across the U.S. (Heiges & O’Neill, 2020). The City of Berkeley did not officially pause the Ordinance; however, City staff and resources were allocated to different relief efforts, the previously allocated budget was not deployed, and the Zero Waste Division in the Public Works Department (which manages the Ordinance) could not hire the allotted personnel, so the City did not have the ability to implement or enforce any components of the Ordinance. The Zero Waste Division was still understaffed and without budget when we collected our final round of data in the fall of 2022. However, in early 2023 the Zero Waste Division filled half of the open staff positions, and began discussions to monitor and enforce the Ordinance.

4.1. Policy Mix

In all phases of the Ordinance, compliance was minimal. However, compliance was relatively higher at the baseline (2019) and had a strong bounce back rate after COVID-19 (2021 and 2022) for the mechanisms that were already commonly adopted by a vendor or expected by customers. For instance, at baseline, 82% of vendors had a self-serve station, thereby providing select foodware accessories by request versus automatically. While the percentage of vendors with self-serve stations dipped in 2020, they rebounded to over half in 2021 (56%) and 2022 (58%). Another example is the percent of vendors that accept a customer’s reusable cup. At baseline, 56% of vendors accepted a customer’s cup. In 2020, that rate dropped to 12%, however, by 2021 it was already back to 36%, then continued rising to 41% in 2022. This trend was similar for vendor employees asking if a customer would like their order “for here or takeout” (SUD or reusable foodware). Employees asked at 58% of vendors in 2019, but that rate plummeted to 5% in 2020 (mostly because on-siting dining was prohibited), then rebounded to 42% (2021) and 41% (2022).

A final example of this trend of a high baseline then strong bounce back in compliance post COVID-19 was the percent of vendors with reusable foodware. 46% of vendors had reusable cups and

food containers at baseline. The percentages dropped in 2020 to 20% for reusable cups and 15% for reusable food containers but increased to 55% for reusable cups and to 38% for reusable food containers in 2021. The percentage of vendors offering reusable cups and food containers continued to increase in 2022, at 61% and 48%, respectively. As one interviewee noted, vendors want to provide reusable foodware because it is a better dining experience for the customer, which is their goal, and which substantiates the speed of return of reusable foodware.

Policy mechanisms that were relatively easy to integrate into a vendor's operations had a steadier adoption rise over the years than those that were more challenging to integrate. In 2019, 67% of vendors offering on-site prepared beverages had SUD cups. There was a gradual rise over the four years of vendors adopting compliant SUD cups (compostable), which is essentially swapping one SUD cup material for another. That is the same for food wrappers, which rose substantially during COVID-19, with a compliance rise from 30% to 91% (2019 to 2020).

The policy mechanisms that required more operational capacity or expense to implement had declining, plateaued, or minimal compliance over the four years. The main example of this is the \$0.25 SUD cup charge. Implementing the charge accurately requires vendors to update menus, the point-of-sale system (cash register) to capture the charge, and receipts. According to an interviewee, that is an operational lift with associated costs that is not prioritized. Additionally, at least in 2020, since a vendor could not accept a customer's cup nor offer a reusable cup because there was no on-site dining, and because the piloted reusable cup service program was paused, vendors felt it was not fair to charge customers for a SUD cup when there was no alternative.

Another example of a mechanism not being implemented due to its operational change requirements is if a vendor has a bussing station, they must also have all three waste receptacles and signage. In 2019, 94% of vendors with a bussing station had the landfill receptacle. Come 2022, not only did fewer vendors with a bussing station have a landfill receptacle (88%), but the percentage of vendors with a bussing station and all three waste receptacles only rose from 23% to 26% over the four years. Adding more waste receptacles may seem like a relatively moderate operational change, however, vendors do not often provide them, in part, because of the additional operations required to manage them and the high customer-driven contamination rate. If the recycling or composting waste stream was contaminated (e.g., had landfill-based waste in them), the vendor could be fined. Since vendors feel there is a lot of customer confusion on sorting material by waste stream, they provide the landfill bin by default which does not have a penalty for material type. Additional statewide regulations enacted during the study's four years require receptacles at vendor sites and support reduced contamination in waste streams. In January 2020, California Assembly Bill 827 – Solid waste: commercial and organic waste: recycling bins (McCarty, 2019), went into effect, requiring vendors to make recycling and composting receptacles available to customers. Then in January 2022, California Senate Bill 1383 – Short-lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills (Lara, 2016) went into effect, requiring organic waste to be sorted via composting, thus putting the potential of fines on landfill receptacles that collected all material (CalRecycle, 2023). Further, as an interviewee noted, even if a vendor complies operationally with the Ordinance, waste stream contamination (which the Ordinance aims to avoid) still occurs because of the customer putting the wrong material in the wrong receptacle, due to the customer's inattention, misinformation, or inaction. To the vendor, especially a vendor struggling with the challenges of rising minimum wage, the labor shortage, and constantly changing regulations because of COVID-19, keeping one, larger landfill receptacle could be operationally easier and more cost effective.

The policy mechanisms that were not authorized during COVID-19 restrictions have advanced minimally, if at all. With on-site dining not allowed under COVID-19 restrictions, the number of vendors with SUD cups and food containers rose substantially between baseline and 2020, then remained high through 2021 and 2022. Additionally, of the foodware accessories provided automatically, there were four more in 2022 than in 2019 (hot lids, bags, cup sleeves, and multiple drink holders), demonstrating the adoption and continuation of practices that adhered to the COVID-19 requirements of takeout or delivery only.

A related change in practice around COVID-19 restrictions pertained to compliant SUD foodware material (compostable). At baseline, only a quarter of vendors had compliant SUD cup material, while over half of vendors had compliant SUD food container material. Over the four years, SUD cup material compliance steadily rose (25%, 28%, 30%, 44%) while SUD food container material compliance increased slightly than dropped (54%, 56%, 49%, 48%). The drop in SUD food container compliance could be due to the large-scale shortage of such material because of supply chain issues (Becker et al., 2020), especially since there was more demand for the items as more vendors were providing SUD food containers (as noted above). Further, one interviewee commented that in the spirit of providing a good dining experience for the customer, they would rather provide a plastic lid than no lid if they no longer have compostable lids.

Overall, with regards to vendors, the Ordinance is overrepresented on destructive policy mechanisms and underrepresented on creative policy mechanisms. There are minimal resources to support vendor compliance and innovation, but there are numerous actions that the vendors now must do (e.g., three waste receptacles) or cannot do (e.g., have non-compliant SUD foodware material).

4.2. Policy Intensity

Policy intensity is the examination of the structure of a policy to assess its strength, and thus potential effectiveness. The structural components include objective, scope, integration, budget, implementation, and monitoring. As of late 2022, the City's Zero Waste Division was still not fully staffed or had access to budget and resources previously allocated to the Ordinance for implementation and monitoring due to COVID-19 orders. This delay in reprioritizing the Ordinance was unlike other jurisdictions across the U.S. which seemed to reprioritize – by regaining access to staff, budget, and resources – their respective anti-SUD foodware policies in 2021 and 2022. For instance, almost immediately after COVID-19 restrictions ended (and in some cases before they ended), fees and bans were reinstated on SUD plastic bags, SUD plastic straws were not provided automatically, and vendors accepted a customer's cup (Upstream, 2022b). In December 2022, the City of Berkeley had not allocated budget, implementation efforts, or plans for monitoring compliance. The delay in reinstating the Ordinance could be, in part, because of the Ordinance's lower policy intensity and the other priorities and mandates the City was facing.

The Ordinance has an *objective* and *wide scope*, both are transparent and ambitious, though the objective could be more specific. The scope is strong in that it disperses winners and losers, plus incorporates mitigation actions, such as allowing vendors to keep the cup charge to offset other compliance costs. However, there could be more mitigation actions for the economic burden faced by vendors and consumers. As for the *integration*, the policy integrates well without conflict or overlap with other, related policies. Further, as a model ordinance, it includes an overarching framework across multiple agencies.

For *budget*, there was a limited and restricted budget for education, awareness, and training; compliance enforcement; technical assistance; a mini-grant program to support vendor compliance; a

pilot program; and assessing socioeconomic impacts, as noted in the Councilmember's referrals to the City Council (City of Berkeley, 2019a). However, that budget was not line-itemed towards the different initiatives and was not deployed at the start of COVID-19. This lack of budget allocation is common for model ordinances (Schaffrin et al., 2015), but it greatly reduces the structural strength of the policy. The City is finalizing a partnership with an outside organization to provide mini-grants for vendors to cover one-time costs associated with transitioning to reusable foodware. This funding will be provided by the City, but again, was not deployed due to COVID-19 but in early 2023 it is on the track to be reopened. This reopening, however, is now contingent on waste service pricing, which will have a rate increase in 2023 after unusually not having a rate increase for a few years. The Zero Waste Division is funded by that rate revenue. The Ordinance does not collect outside revenue to support City staff time. In some anti-SUD foodware policies, the fees collected from customers (e.g., \$0.25 fee on SUD cups in Santa Cruz County, California), partially or fully go to the city or waste service provider to support waste reduction efforts and policy compliance. For the Ordinance, the \$0.25 on SUD cups are collected by vendors – which is not taxable – to offset their costs for the more expensive compliant SUD foodware material and to gain vendors' support during the Ordinance's creation. That means in Berkeley there is no increased revenue generated by the policy to financially support the work that already has a limited and restricted budget and personnel.

The Ordinance allocated the City Manager to oversee *implementation* as a catch-all for monitoring and enforcing. The City Manager is the only stakeholder prescribed monitoring and enforcement roles, which lowers the operating costs (Schaffrin et al., 2015), but overburdens a department that is already resource strapped. The City Manager is referred to by City Council and does not have the authority to direct individual departments (like the Zero Waste Division). Instead the Council directs the City Manager to collaborate with departments. Therefore prescribing roles only to the City Manager, while common, created a gap of responsibility. Also, vendors need to take action for compliance, but they are not overtly prescribed roles. The gap in City staff responsibility, conflicting directives vendors received from the United State's Centers for Disease Control and Prevention (CDC) and the City's Health Department, and required vendor action, according to the vendor interviews, contributed to vendor and customer confusion on Ordinance mechanisms, vendor non-compliance with the mechanisms, vendor frustration over the mechanisms, and lack of vendor awareness of the grants and waivers (even though the waiver was included in the initial City notification letters about the Ordinance). It should be noted, however, that role designation and personnel to support initiatives is not commonplace in a model ordinance, so while this omission reduced the policy's intensity, it does allow the Ordinance to be more easily replicated in other jurisdictions. Moreover, the Ordinance does note implementation through a three phased approach, and that enforcement will occur a year after enactment. Finally, as one City staff member noted, part of the lack of progress on the implementation of the Ordinance was not just because of delays caused by COVID-19 but also because of the relatively slower speed at which local governments operate.

The final measure is *monitoring*. Since budget was not clearly defined, and all available City budget, personnel, and resources were not deployed or were reallocated due to COVID-19, the City has not yet been able to monitor compliance. Further, the City never intended to be particularly rigid with monitoring, and especially did not want to add additional burdens to vendors hardest hit by COVID-19. One media outlet poignantly summed up the city's monitoring approach: "The spirit of this legislation is to partner with [prepared] food vendors to make transitions workable – and effective. Implementation is phased, and enforcement of each phase will focus on helping businesses make the transition" (Plastic Pollution Coalition, 2019). This is complaint-based enforcement that deprioritizes punitive measures. It is possible that the lack of monitoring during the data collection period decreased accountability for vendor compliance with the Ordinance.

4.3. Niche-Innovation Specificity

Of the five policy mechanisms that aimed to foster three niche-innovations, all resulted in a higher rate of compliance with the mechanism between 2019 and 2022, and thus advancement for the niche-innovation, except in one sub area. There are three distinct trends with regards to compliance and niche-innovations.

The first trend is that three mechanisms had vendor compliance drop during COVID-19 (2020), but experienced a bounce back in compliance to rates higher than baseline. These mechanisms were the requirement that only reusable foodware is used for on-site dining (reusable foodware niche-innovation); that if a vendor has a bussing station, it must also have all three waste receptacles with signage (alternative materials niche-innovation); and that foodware accessories are provided by request or at a self-serve station (material reduction niche-innovation). The latter two became state laws during this data collection timeframe. The first, pertaining to the three waste receptacles, is covered in both Assembly Bill 827 (McCarty, 2019) and Senate Bill 1383 (Lara, 2016), which went into effect January 1st, 2022. The second, pertaining to foodware accessories not provided automatically, is Assembly Bill 1276 – Single-use foodware accessories and standard condiments (Carrillo, 2021). It is unclear if the passing of these California laws influenced compliance by vendors with the similar mechanisms in the Ordinance. However it adds to the mandate for the City to do enforcement as they are required now by state law in addition to their own policy.

The second trend is that compliance with the mechanism increased over the four years, so the niche-innovation developed over the four years. This was found with vendors increasingly complying with the mandate that all SUD cups must be compostable, which is one sub-area that all SUD foodware must be compostable (alternative materials niche-innovation), and that vendors implement a \$0.25 charge on SUD cups as well as mention the charge pre- and post-sale (material reduction niche-innovation). Concurrently, in the 2019-2020 California legislative session, Assembly Bill 619 – Retail food: reusable containers: multiuse utensils (Chiu, 2019), was signed into law, which allows vendors to accept a customer's reusable cup (and food container, however food containers are not currently part of the Ordinance's purview). That law helps clarify a section of state health code by removing legal ambiguity. This law went into effect immediately, in July 2019. However, many vendors have opted not to accept customers' cups and containers due to their own liability and employee safety concerns.

The final trend is reduced compliance with a policy mechanism in 2022 compared to 2019. This only occurred for the mandate that all SUD food containers must be compostable, which is the other sub-area to all SUD foodware being compostable (alternative materials niche-innovation).

At the start of the pandemic, all on-site dining was eliminated, third-party reusable foodware providers were revoked, customers could not use their own reusable cup, and the Ordinance was effectively paused. We thought there would be no progress on compliance with the Ordinance and that there would be a large backsliding of the decades-long anti-SUD foodware accomplishments. There was a COVID-19 impact for two mechanisms, however, over the four years, compliance with the Ordinance improved for almost all facets. The improvements are not necessarily large and there is still, on average, minimal compliance with most mechanisms; however, there is progress towards the three niche-innovations.

4.4. 2023 Ordinance and City Staff Update

Our data collection, and thus analysis, ended in 2022. However, many relevant changes to the Ordinance and City staff have since occurred, prompting us to share an update. In the start of 2023, the

Zero Waste Division was about half staffed and therefore better able to proceed with the originally allocated staff, resources, and budget towards implementing and monitoring the Ordinance. City staff noted that they plan to collaborate with different stakeholders to promote education, awareness, and training on the Ordinance, prioritizing the vendor stakeholder group. Additionally, they are formalizing a partnership with ReThink Disposable through Alameda County's Waste Management Authority (StopWaste), on providing the technical assistance mini-grants. The City is also in collaboration with a University of California, Berkeley student group, PlateUp, to provide technical and material assistance, funded through the University's Student Environmental Resources Center. Monitoring will have two approaches: one from City staff as they continue to do site visits with vendors for compliance with related policies (composting requirement, SUD plastic bag ban, etc.), and through customer complaints noted through the City's 311 system. The Ecology Center also plans to conduct monitoring and outreach with vendors. These efforts were absent during the data collection period, and thus provide a new layer of budget, implementation, and monitoring. Furthermore, the City is preparing and formalizing the penalty process, should a vendor fail to comply after receiving a warning.

4.5. Recommendations

First, we want to acknowledge that a lot of work, consideration, collaboration, and revisions took place to create the Ordinance, which was an unprecedented anti-SUD foodware policy. A thorough dedication to that work can be found in the Ecology Center's Disposable Free Berkeley toolkit (Ecology Center, 2023). Our below recommendations are based on a predominantly quantitative study, conducted right before, during, and immediately after COVID-19, which was also unprecedented. It is impossible to concretely isolate vendor compliance with the Ordinance due to its mechanisms, structure, and niche-innovation versus COVID-19. Having baseline data as well as a longitudinal data set helps, but only correlational analyses can be drawn. Below are recommendations to make the Ordinance more effective by increasing vendor compliance.

Before we go into the specific recommendations based on the three measures for effectiveness, we want to note that anti-SUD foodware – for the Ordinance and in other jurisdictions – must become more equitable. For instance, if there is a charge on SUD items, there must be an equitable alternative for customers, and vendors should not be incentivized to implement the charge solely for financial gain. The Ordinance made some advancements such as waiving the cup charge for individuals with WIC and EBT and by requiring all vendors to have SUD plastic straws on-site in case one is requested for accessibility purposes; however, what else can they do to advance support for those with disabilities to feel included in and co-creators of this movement? Historically, not everyone is included in the early stages of a sustainability transition (Köhler et al., 2019). Berkeley must aim to foster an inclusive sustainability transition.

We recommend removing part of the perverse incentive of vendors to keep the SUD cup charge by funneling partial revenue to the City to financially support waste reduction efforts and/ or create additional technical assistance grants for vendors to transition to reusable foodware. We also recommend a stipulation that vendors may only implement the SUD cup charge if they have compliant SUD cup material and they either have a reusable cup option or accept a customer's reusable cup (Heath, 2023). This has been an issue with one national vendor implementing the SUD cup charge, but none of the elements and expenses that the charge is supposed to cover. To specifically bolster creative policies with regards to vendors, this could include data transparency on compliance, a platform to share learnings and successes, financial incentive for implementing reusable foodware systems, and incorporate research and development funding schemes to support vendors in testing innovative types of reusable foodware systems.

We recommend increasing the ordinance's intensity by strengthening the three components underrepresented: budget, implementation, and monitoring. The budget should include City Manager (staff) time, physical costs, and ongoing costs. For implementation, the Ordinance is presently too reliant on City staff as the main actor, since they are the only ones with actionable authority. The City should delegate roles and responsibilities to other key actors of influence, for items like sharing best practices, such as business improvement districts, the chamber of commerce, customers, delivery services, and vendors. However, the City staff should continue and increase outreach and education to vendors and customers. For monitoring, we recommend coupling monitoring with other monitoring activities (e.g., for food health and safety, for California's Senate Bill 1383 legislation on compostable food), which the City has informally begun in 2023. Further, we recommend requiring vendors to comply with the policy in their annual business license renewal like what is done for the ban on expanded polystyrene foodware, or having progressively larger fines for noncompliance violations like with the ban on SUD plastic bags. We also recommend increasing the non-monetary consequences for non-compliance to also include legal action from the City, and restricting and/ or revoking business licenses and permits.

Our third set of policy-specific recommendations pertains to fostering a reusable foodware system. To move reusable foodware systems forward, policies such as the Ordinance are essential. However, the Ordinance was too reliant on vendors providing reusable cups for on-site dining and customers bringing a reusable cup as the mechanisms to foster a reusable foodware system. There needs to be more alternative reusable foodware system options (e.g., third-party providers, return schemes) so it is not a large additional operational item for vendors and it is more equitable for customers.

4.6. Limitations

The adoption of the Ordinance, our data collection, and COVID-19 all coincided. It is therefore impossible to separate conditions of the Ordinance and COVID-19; there is no counterfactual to demonstrate what vendor compliance would have been with the Ordinance without COVID. Additionally, COVID-19 slightly disrupted the methodology, which eliminated our ability to gain insight into the quantity and type of SUD foodware waste generated. Further, this evaluation occurred right before, during, and immediately after the Ordinance's three scheduled phases. It is therefore a short-term (under two years) evaluation of a policy's effectiveness, and there will likely be different results from a long-term (over two years) evaluation of a policy's effectiveness (Diana et. al, 2022).

Another limitation was our small sample size of vendor interviewees. Early on it became clear that we did not have the time or resources to collect the desired number of interviews and that our interview pool – managers at vendors – were difficult to interview because of their limited time. The interviews we did conduct were insightful and any insight is noted as not a representative or generalizable insight.

4.7. Future research

Now that the COVID-19 lockdown mandates seem to be behind us, we recommend collecting the same data for at least another two years to gain insight on the emerging effectiveness trends of the Ordinance. The City already appears to be implementing some of our above recommendations (that we have given them and that they have received through other forums). So, additional years of data collection would inform if changing City action influences vendor compliance. That insight, in turn, could inform adjustments to the Ordinance or the creation or development of similar policies in other jurisdictions. Further, while it was out of scope for this study, we recommend conducting a more thorough comparative evaluation between jurisdictions with an anti-SUD foodware policy and

neighboring jurisdictions without one. Specifically, it would be important to analyze the possible connection between the Ordinance and the subsequent three state laws that include anti-SUD foodware mechanisms from the Ordinance (Assembly Bill 827 (McCarty, 2019), Senate Bill 1383 (Lara, 2016), and Assembly Bill 1276 (Carrillo, 2021)), as well as the 44 other, similar policies enacted in California after the Ordinance was passed (Upstream, 2022b).

With regards to the creation or development of similar policies in other jurisdictions – as part of the sustainability transition of anti-SUD foodware policy – we recommend experimental research to assess the differences between such policies based on that jurisdiction’s context. This research could strengthen policies by gaining nuanced perspectives, thus building a more resilient and effective policy-based anti-SUD foodware sustainability transition. Some topics may include the standardization of terminology, what types of vendors must comply with the policy, if there are multiple policies or a multi-mechanism policy, where the SUD foodware charge revenue goes, and if there are rigorous studies that might influence the policy’s implementation (e.g., Programmatic Environmental Impact Report). Additionally, we recommend a translational study on expanded polystyrene (EPS) bans because that material is no longer prevalent in some jurisdictions with such a ban (Wagner, 2020). Since this study created and leveraged a replicable tool for capturing and evaluating anti-SUD foodware policy effectiveness, we recommend using that tool to standardize insight and comparability for future, related studies.

In this study, we captured the effectiveness of the Ordinance through vendor compliance. It would also be informative to capture Ordinance effectiveness through waste generation, including the amounts and types of waste generated, which both the City and County plan to do in 2023. Similarly, to obtain a more comprehensive perspective of the effectiveness of the Ordinance, it is important to gain financial data such as the change in revenue and expenses to vendors.

A shortcoming of our research was that it did not include an analysis of SUD foodware waste generated in the delivery process. With COVID-19, there was a proliferation of delivery (by the vendor and with a third-party provider), which likely had different types and amounts of SUD foodware than takeout.

5. Conclusion

In January 2019, City Councilmembers in Berkeley, California unanimously approved the Single Use Foodware and Litter Reduction ordinance. This policy, as part of the sustainability transition grounded in anti-single use disposable (SUD) foodware policies, was unprecedented as it incorporated five different policy mechanisms aimed to foster a reusable foodware system, alternative SUD foodware material, and reduce SUD foodware waste. Upon passing, the Ordinance was considered a model ordinance for jurisdictions across the world to implement. However there were no plans to analyze the Ordinance’s effectiveness before such implementations were to occur. We therefore conducted this study to inform the direction of this model ordinance for both Berkeley and other jurisdictions to more effectively reduce the amount of SUD foodware waste generated, littered, and disposed.

The Ordinance required a lot – such as new infrastructure, multiple avenues of education, wide scale compliance, and behavior change by all relevant actors – to proceed as envisioned. That might have been possible, but thirteen months into it, COVID-19 hit. The City, rightfully, reallocated budget, personnel, and resources to support COVID-19 mitigation and relief efforts. While the Ordinance was never paused, it was deprioritized. This study, which collected data right before, during, and after COVID-19 demonstrates the effectiveness of the Ordinance amid a pandemic. We attempt to parse out components of the Ordinance’s effectiveness but acknowledge that it is all filtered through the lens of

the pandemic. It is likely that COVID-19 accentuated weaknesses in the Ordinance versus bolstered any strengths, and it is unclear if those weaknesses would have been prominent without COVID-19.

Overall, the Ordinance had a strong mix of policy mechanisms but could include more creative policies to balance the overrepresentation of destructive policies. To strengthen the structure of the Ordinance, it needs a clearly defined and allocated budget, implementation, and monitoring. Finally, the Ordinance was unprecedented in fostering reusable foodware, which it should continue to do, but be less reliant on that niche-innovation and put more financial support and resources toward not only that one, but also toward alternative SUD foodware materials and reducing SUD foodware waste.

Supplemental Material

Table S.3.1: The observational quantitative survey. Below is the survey used over the four years (with a slight adjustment due to COVID-19 restrictions).

Email Address	Possible pre-fill answers, separated by semicolons
Surveyor's name	
Date	
Time	
Day of week	Monday; Tuesday; Wednesday; Thursday; Friday; Saturday; Sunday
Vendor name	
Address of vendor site	
Is the order paid for at the counter or at the table?	Counter; Table
Is the order served at the counter or at the table?	Counter; Table
Is food and drink production batch, just-in-time or both?	Batch; Just-in-Time; Both; N/A
Hours of operation	Morning/ afternoon; Afternoon/ evening; All day
Type of food business	Bakery; Food products store; Food service establishment; Theater; Food truck; Farmer's market; Gas station
Is there on-premises seating	Yes; No
Number of indoor seats (enter 0 if none)	
Number of outdoor seats (enter 0 if none)	
Number of self-served stations (enter 0 if none)	
Number of bussing stations (enter 0 if none)	
Which waste bins are there?	Landfill; Recycling; Compost; N/A

Is there signage for the waste bins?	Yes, images; Yes, words; No; N/A
Do employees ask customers if their order is for-here or takeout?	Yes, employees ask; No, employees do not ask
[Orders that are "for-here"] Are beverages served in a reusable cup?	Yes; No; N/A
[Orders that are "for-here"] Is food served on reusable dishware (e.g. washable dish)?	Yes; No; N/A
[Orders that are takeout] Is the customer asked if they need a SUDs cup or is it just assumed?	Yes, customers are asked; No, it is assumed; N/A
[Orders that are takeout] Does the business accept a customer's reusable cup?	Yes; No; N/A
If the business accepts a customer's reusable cup, is there any price difference?	Yes; No; N/A
If there is a price difference, what is it (in \$)? Put "N/A" if there is no price difference.	
Does the business charge the \$0.25 disposal cup fee?	Yes; No; N/A
Which SUDs foodware accessories are provided automatically?	Straws; Hot lids; Cold lids; Sleeves; Utensils; Sugars/ condiment packets; Napkins; Multiple drink holders; Carryout bag - handles (e.g. paper or plastic bags with handles like a shopping bag); Small bag - no handles (e.g. bags for baked goods, lunch bags for sandwiches or burritos); None of the above; Other
Which SUDs foodware accessories are provided by request or at the self-serve station?	Straws; Hot lids; Cold lids; Sleeves; Utensils; Sugars/ condiment packets; Napkins; Multiple drink holders; Carryout bag - handles (e.g. paper or plastic bags with handles like a shopping bag); Small bag - no handles (e.g. bags for baked goods, lunch bags for sandwiches or burritos); None of the above; Other
For takeout options:	The vendor has order ahead/ pick-up; The vendor has delivery; The vendor has ordering takeout while in person (e.g., ordering takeout); N/A (this answer would be rare)
What is the price of a cup of a standard drink (e.g. drip coffee, classic milk tea)? Write the drink, size, and price (e.g. coffee, 12oz, \$2.50).	
Is a receipt given automatically or by request?	Automatically; By request; No receipt was given

If a receipt is given, is it paper or electronic?	Paper; Electronic; No receipt was given
Does the receipt break out a \$0.25 charge?	Yes; No
Is the \$0.25 charge mentioned anywhere?	Sign/ menu board; Individual menus; Employee mentions it; Receipt (answer should match the previous question's answer); No, the charge is not mentioned anywhere
Does the business offer free, bulk water? (e.g. water refill station)	Yes; No
If yes, what type of cup do they offer with the water?	Plastic; Compostable plastic; Paper/ fiber non-compostable; Paper/ fiber compostable; Reusable; No free, bulk water is offered
[SUDs] Plastic cups	Yes; No
[SUDs] Compostable plastic cups	Yes; No
[SUDs] Paper/ fiber non-compostable cups	Yes; No
[SUDs] Paper/ fiber compostable cups	Yes; No
[SUDs] Other types of SUDs cups (explain)	
[Reusable] Hard plastic cups	Yes; No
[Reusable] Ceramic cups	Yes; No
[Reusable] Glass cups	Yes; No
[Reusable] Stainless steel cups	Yes; No
[Reusable] Customer's personal cup/ mug	Yes; No
[Reusable] Reusable cup service program	Yes; No
[Reusable] Other types of Reusable cups (explain)	
[SUDs] Plastic food containers	Yes; No
[SUDs] Compostable plastic food containers	Yes; No
[SUDs] Paper/ fiber non compostable food containers	Yes; No
[SUDs] Paper/ fiber compostable food containers	Yes; No
[SUDs] Wraps/ small bags	Plastic (e.g. Saran wrap); Compostable paper (e.g. bags for baked goods, lunch bags for sandwiches or burritos, non-wax-lined butcher paper); Non compostable paper (e.g. wax-lined butcher paper); Tin foil; N/A (no wraps/ small bags)

[SUDs] Other SUDs food containers (explain)	
[Reusables] Hard plastic food dishware	Yes; No
[Reusables] Ceramic food dishware	Yes; No
[Reusables] Glass food dishware	Yes; No
[Reusables] Stainless steel food dishware	Yes; No
[Reusables] Other Reusable food dishware (explain)	
Please add anything of note that was not captured above	

Chapter 4

A Recycling Reckoning: How Operation National Sword catalyzed a transition in the U.S. plastics recycling system

This chapter was previously published (Heiges & O'Neill, 2022a) and is included here with permission from co-authors

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Abstract

The U.S. plastics recycling system was not built methodically over past decades. It accepted plastics that had no market, relied too heavily on exporting material and to a single primary purchaser (China), and allowed high rates of contamination which meant low actual recycling rates. When China no longer wanted to or needed to purchase such low-quality material – through 2018's "Operation National Sword" – the U.S. plastics recycling system underwent a reckoning. This was a widespread, abrupt, surprising, and impactful disruption to the system, potentially altering the system entirely. That altered system would come from a transition. We use the multi-level perspective (MLP) transition framework, and recommended updates to better understand if amid this disruption, a single 'niche-innovation' will emerge as the new U.S. plastics recycling system leader or if multiple niche-innovations will occupy that role. We suggest that the emergence of multiple niche-innovations can support a sustainable, just, and methodical transition of the plastics recycling system more effectively, as well as demonstrate an additional transition 'pathway' not previously considered in transition theory, namely the formation of multiple, co-existing regimes. Furthermore, we discuss the importance, yet potential shortcomings, of analyzing an emerging transition in the moment.

1. Introduction

Recycling – the process of transforming a material from its original shape and use to something new for an extended life – began in the U.S. to use and convert resources more economically. Initially, recycling services were located near metal or paper/fiber manufacturing facilities, so transportation to local processors was efficient. In the 1960s, demand for resources for goods and packaging increased, thereby amplifying the benefits of recycling and expanding services to collect additional materials, such as the newly popular plastics (MacBride, 2011). This expansion was boosted by the public's growing awareness of the environmental harms of a consumer society (Cohen, 2003) and the plastics manufacturing industry's assurances that recycling was effective. However, not all those additional materials (and their higher quantities) could be processed in the preexisting recycling facilities, which lead to searching for entities that were willing to purchase the material: other countries (MacBride, 2011; O'Neill, 2019). The U.S. plastics recycling system and its increasingly export-dependent structure was therefore not built through the development, maintenance, and enhancement of sound, methodical recycling practices and technologies. Instead, it relied on the negotiation of rules, stakeholder power and preferences, ecological values, and markets (MacBride, 2011).

The institutional complexity of this system meant that in recent decades it became subject to neglect and stasis. Little new recycling infrastructure had been built since the early 2000s, and the that which existed received little maintenance (O'Neill, 2017). While most other wealthy nations have some

form of centralized, national, or supranational governmental regulatory framework for wastes and recycling, the U.S. system remained decentralized, with rules and practices differing substantially across states, counties, and cities (Mouw et al., 2020). Actors within this system paid little attention to developing domestic markets for recycled plastic material. Until 2018, material recovery facilities (or municipal sorting facilities) relied on export markets, specifically plastic recycling companies in China. However, at that point, as we explain below, China cracked down almost entirely on imports of plastic scrap, throwing the U.S. plastics recycling system into disarray and forcing its actors to suddenly consider rebuilding their domestic capacity. China's new policy, announced in 2017 and implemented in 2018 is commonly called "Operation National Sword."

In this article, we investigate where the U.S. plastics recycling system stood before Operation National Sword and the emerging transitions – or *impacts* and *solutions* – that have begun since. Our primary research question is: How did the announcement of Operation National Sword catalyze a reckoning in the U.S. plastics recycling system? Our secondary research question is: If the U.S. plastics recycling system is undergoing a reckoning, what type of transition is it now experiencing? We explore these research questions, utilizing transitions theory, notably the Multilevel Perspectives (MLP) framework developed by Geels (2002, 2005a, 2005b, 2006a, 2006b, 2011) and others (Berkhout et al., 2004; Geels & Schot, 2007; Geels et al., 2017; Smith et al., 2005; Suarez & Oliva, 2005). The MLP has five transition pathways that categorize a transition based on certain characteristics: the amount of global pressure (no pressure to some pressure), how developed or 'ready' the small-scale innovation is (not at all, developed, or multiple niche innovations), and the type of external environmental change (regular change, hyperturbulence, specific shock, disruptive change, avalanche change). First, we outline the "avalanche change" (an infrequent, high impact and quickly occurring event; Suarez & Oliva, 2005) that shook the U.S. plastics recycling system in 2017/18. We then review transition theory literature to elucidate why we chose to analyze the impacts of Operation National Sword through the sociotechnical transitions of the MLP.

In our empirical sections, we demonstrate how the U.S. plastics recycling system, or *regime*, in MLP terms, was ripe for a reckoning before Operation National Sword was announced.⁷ That reckoning was many years in the making due to the non-methodical development of the regime and the *niche-innovations* that either failed or persisted within the increasingly locked-in U.S. plastics recycling system. Finally, by analyzing the impacts and solutions implemented in the U.S. plastics recycling regime after Operation National Sword, we argue that it is amid a transition, most appropriately categorized as a *de-alignment* – the breakdown of the regime – followed by either a *re-alignment* – the creation of a new regime – or the creation of multiple new regimes. At the time of this paper (2022), the U.S. plastics recycling system has not yet entered the re-alignment or multiple new regimes phase.

We also offer insights regarding the MLP framework, including the role of numerous actors across spatial scale, the non-linearity of transitions, emerging outcomes, and the effect of multiple outcomes. We also expand on the MLP framework through a real-time – not historically retrospective – analysis of a transition, that not all de-alignments result in re-alignments, and that there might be an additional transition pathway within the framework.

⁷ We focus on plastic scrap in this article because it was most directly impacted by Operation National Sword, and its recycling was already deeply problematic. Operation National Sword had serious impacts on paper and cardboard recycling too, as well as knock-on effects on other kinds of recycling, such as glass (O'Neill, 2019). We also note that other kinds of scrap – such as aluminum, copper, and steel – maintain their value in the recycling process and there are still functioning domestic and international markets for them.

2. Operation National Sword: An Avalanche Change

Starting in the 1990s, China's booming economy began to propel it towards its status today as the center of global manufacturing. However, at the outset, China's demand for raw materials far outstripped its domestic capacity to produce or extract them. Manufacturing or importing plastic was expensive while importing used plastic was relatively affordable, so China began importing plastic scrap from across the world. By the early 2000s, China was the leading importer of scrap materials in the world. That continued into the 2010s, with plastics exports to China from the U.S. totaling 1,500 shipping containers daily (Flower, 2016). O'Neill (2019) notes, "in 2016, [China] accounted for 27 percent of all global waste and scrap imports, including 55 percent of the world's copper scrap, 24 percent of its aluminum, 55 percent of its paper scrap, and 51 percent of global plastic scrap" (p.154). In that same year, it received 70% of the U.S.'s plastic scrap (Katz, 2019). Due to the high demand from its manufacturing sector, Chinese companies were accepting plastic scrap bales, even with high contamination rates, which resulted in high disposal and mismanagement versus utilization rates (Jambeck et al., 2015; Law et al., 2020).⁸

In 2017, China imported 5.7 million metric tons (Mt) of plastic from around the world (Staub, 2019). That year, the Beijing government announced its intention to radically restrict its imports of plastic and paper scrap: the imposingly titled Operation National Sword. Specifically, Operation National Sword enacted new and highly stringent technical standards for the remaining imported materials, including contamination limits of 0.5% for post-consumer plastic. China's import of the world's plastic scrap plummeted to 50,000 Mt (Staub, 2019). Operation National Sword also set off a cascade of trade restrictions in other previously high import countries, such as Vietnam, Indonesia, Thailand, Taiwan, and Malaysia (CalRecycle, 2021), therefore preventing U.S plastics recyclers from simply finding alternative markets in the region. The U.S. exported 1.25 million Mt of plastic in 2017 (UN Comtrade Database, 2021). In 2018, that number was 908,000 Mt and it continues to drop, with under 600,000 Mt of plastic exports in 2021 (UN Comtrade Database, 2022).⁹

Operation National Sword was unprecedented, arrived with little warning, and had enormous ramifications across sectors, economies, governance structures, trading partnerships, and geographies. The effective closing of the U.S. and world's largest scrap importer sparked a seismic shift in the handling and processing of scrap materials. While this avalanche change was unexpected it was also – as subsequent sections show – well overdue.

⁸ Contamination includes dirty plastics or other recyclables, and also mixed plastics or other objects that render the bale too difficult to sort and recycle effectively or efficiently. For more, including on the types of plastics manufactured and consumed, see Heiges and O'Neill (2022).

⁹ Beijing's motives were complicated (O'Neill, 2019). In part, as the world's leading economic power, it no longer wanted to be seen as the "world's dumping ground" (hence the tagline for the policy – "No More Foreign Garbage"). Additionally, with China increasingly generating its own plastic scrap, it did not necessarily need imported scrap to contribute to its recycling system. Regardless of the motives, Operation National Sword's impacts were immediate and severe for the U.S. plastics recycling system as well as for the other countries, like the UK and Australia, that were dependent on China for dealing with their plastics (O'Neill, 2019).

At the time of the announcement of Operation National Sword and over the weeks that followed, the U.S. plastics recycling sector reacted with shock. Industry leaders predicted the U.S. plastics recycling system would collapse (Cole, 2017; Margolis, 2018). There were pleas for widescale, coordinated political mobilization – not unlike wartime efforts – to fix the ensuing catastrophe (Nielsen et al., 2020) and discussions that waste-free innovations were needed immediately (Ellen MacArthur Foundation, n.d.-a; Iles, 2018). This response was compounded by the immediate and large reduction in the value of scrap plastic, paper, and cardboard (See *Supplemental Material – Market Prices for Plastics* for the market prices for plastics during this time period) (Recycling Markets, 2021). Operations at material recovery facilities (MRF) – often termed ‘recycling centers’ – slowed to better sort material to accommodate the stricter contamination thresholds, U.S. exporters frantically sought alternative international markets, and recycling programs across the U.S. reduced their intake of materials or paused all services (Rosengren et al., 2019).

This response was not unfounded, given the immediate and potentially far-reaching uncertainty of the U.S. plastics recycling system after a decades-long undiversified market reliance on China. However, predictions – such as the entire U.S. plastics recycling system collapsing (Hook & Reed, 2018; Recycle Across America, 2020; Roston, 2019; Sheeler, 2019) – have not yet been realized. Instead, the reality of the emerging transition is much more complex, with some positives (e.g., innovations, investment (Lehtinen & Ekengren, 2020; Orsini, 2021)) and some setbacks (e.g., shutting down recycling programs, halted progress on policy advancements, increased disposal in landfills and incinerators (Rosengren et al., 2019)). This chaos and instability can be best described as the U.S. plastics recycling system being in the middle of the de-alignment phase of a sociotechnical transition. We explain the framework we adopt to identify this change and to predict pathways in the next section.

3. A Sociotechnical Transition: The Multilevel Perspective Framework

3.1 The Multilevel Perspective

There are many types of transition frameworks that assess the actors, context, intent, and outcomes of intended and unintended transitions (e.g., Delina & Diesendorf, 2013; Genus & Coles, 2008; Meadows, 2008; Seto et al., 2016). We selected the MLP framework for our transition analysis. It uniquely breaks out three heuristic, analytical levels and contextualizes transitions via pathways based on their *timing* and *nature of interaction* (Geels & Schot, 2007) which are particularly applicable to our case. Advantages of the MLP as a transition framework are that it is multi-level and cross-scalar, it is both variable and interactive, and it is inherently socio-technical (integrating technology and politics as part of a complex system). The MLP has been used to retroactively analyze numerous large-scale sociotechnical transitions like horse-drawn carriages to automobiles (Geels, 2005a), cesspools to sewer systems (Geels, 2006a), agroecological transitions (Anderson et al., 2019), low-carbon transitions (Geels et al., 2017), and smart cities (Mora et al., 2020).

The three heuristic, analytical levels within the MLP are niche-innovations, regimes, and landscape. Figure 4.1 shows the three levels with examples from the U.S. plastics recycling system mapped to the corresponding levels. Niche-innovations include small-scale, local initiatives. They are often risky and have uncertain long-term viability. They have not fully permeated society, even on a local level, but are iterating to gain traction and a stronghold. Niche-innovations in the energy regime are renewable energy technologies, in the governance regime are localized policies to reduce industry lobbying, and in the agricultural regime are market systems to support farm-to-table production. Regimes hold the components that make up complex sociotechnical spaces, including markets, industry,

science, culture, policy, and technology. Regimes are the stable, sometimes ‘locked-in’ institutions that influence societal and political norms, often creating path dependency with limited, incremental change (Köhler et al., 2019; Seto et al., 2016). A regime is defined by its boundary (e.g., a state or nation) and the system in which it explains (e.g., all modes of transportation or solely automobiles). Finally, landscapes are the macro-level influences on regimes and niche-innovations: macroeconomics, cultural norms, and macro-political trends. Landscapes put pressure on regimes, influencing their level of stability. A transition is the change from one regime to another. For instance, a transition can occur when a ‘dynamically stable’ regime becomes unstable through landscape volatility, or if a niche-innovation gains traction and displaces a pre-existing regime player. However, actors within a dominant regime can catalyze structural changes from within the regime (e.g., governments enacting a new policy).

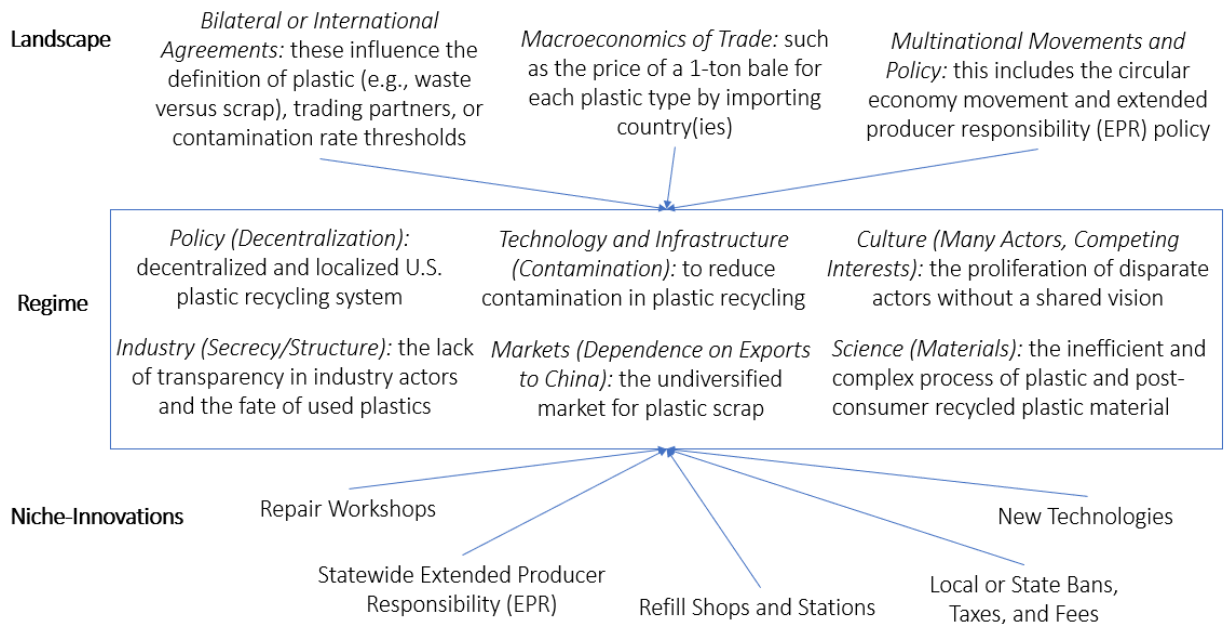


Figure 4.1: The U.S. national plastics recycling system mapped via the MLP framework.

The five *transition pathways* as outlined by Geels and Schot (2007) are the reproduction process, transformation, reconfiguration, technological substitution, and de-alignment and re-alignment. These pathways are categorized by the timing and nature of the interaction between the niche-innovation, regime, and landscape levels. The reproduction process is when a regime reproduces itself, stably, in the absence of disruptive niche-innovations or landscape pressures. The transformation pathway is when regime players alter the direction of development based on moderate landscape pressure and insufficiently developed niche-innovations. The reconfiguration pathway is when multiple cooperative niche-innovations disrupt the basic structure of the regime. The technological substitution pathway is when there is a sudden and substantial landscape change and niche-innovations are sufficiently developed to replace the disrupted regime. Finally, the de-alignment and re-alignment pathway is when there is a sudden and substantial landscape change (like with technological substitution), multiple niche-innovations compete to fill the voided regime, however, only one succeeds.

3.2 Critiques of the MLP

One critique of transition theory, predominantly aimed at the MLP, is that it is too generalist; it makes too many assumptions, distills complex situations too narrowly, and is too deterministic (Wilson, 2007). Transitions are complex, adaptive systems, not linear, as often represented in the MLP. Wilson (2007) argues the four fallacies perpetuated in transition theory are temporal linearity, homogenous spatiality, global universality, and structural causality. His recommended four alternative approaches, respectively, are temporal non-linearity, spatial heterogeneity, global complexity, and structure-agency inconsistency.

Other critiques of the MLP include that its focus on post hoc analysis versus examining ‘in-the-making’ cases with temporal diversity, that are destabilizations versus breakthroughs, have dialectical process models, or are theoretical templates for policy processes (Köhler et al., 2019). Additionally, there is much subjectivity involved in the MLP framework, including the boundary (start and end points of a transition and how those are defined), what data are analyzed, how the researchers interpret those data (Genus & Coles, 2008), and determining if the transition has an end state or a new stable state. Furthermore, some argue that the negative connotation surrounding a ‘failed’ transition is a harsh judgement; instead, it can mean a transition that remains incomplete, (although perhaps only for the moment), which can be due to lack of momentum or a persistent lock-in (Seto et al., 2016; Wilson, 2007) and that insight and lessons can still be valuable. An example of this in the renewable technology space is wind turbines which seemingly ‘failed’ a century ago but since 2005, an average 3,000 wind turbines are installed annually in the U.S. (USGS, n.d.).

We offer an additional critique of the MLP framework not presently found in the literature (Geels, 2011). That is, another type of transition pathway exists, one that leads to the creation of new, distinct, *multiple* regimes instead of simply a singular one. Geels and Schot (2007) have a void for transitions that occur much like those following evolutionary biologists Niles Eldredge and Stephen Jay Gould’s (1972) punctuated equilibrium: where there are periods of stasis (no evolutionary change) punctuated by the rare and rapid change that result in two new species (*speciation*).¹⁰ This is different from Geels and Schot’s five transition paths, even when updated with Suarez and Oliva’s five types of environmental change (regular change, hyperturbulence, specific shock, disruptive change, and avalanche change) because it notes that change can result in multiple new regimes. We discuss these multiple, coexisting, potentially competing regimes for the U.S. plastics recycling system in the *What’s Next? A Re-Alignment or Multiple New Regimes?* Section.

3.3 Methodology

We modified the Geels and Schot (2007) MLP framework by leveraging it to conduct a real-time transition analysis, an approach we hope future sustainability transition researchers take. We do not argue that a transition is happening in a linear fashion, instead recognize that it is unfolding as we write, and was and remains highly complex and contingent. Such an approach is fraught with assumptions due to limited data availability and constantly emerging and shifting interactions between niche-innovations, the regime, and landscape developments. However, the approach is also important to better understand the status of the transition to inform action towards a more sustainable and just U.S. plastics recycling system. With the in-the-moment MLP framework set, two methodological components were needed to conduct this research: defining the boundaries and determining which transition

¹⁰ The punctuated equilibrium framework is often utilized to explain change in political systems and historical institutionalist literature too. See, for example, Baumgartner and Jones (2009) and Lundgren et al. (2018).

pathway the U.S. plastics recycling system was undergoing. We also outline how and where we collected our data.

One of the more difficult components of this research was defining the boundaries of the regime because the U.S. plastics recycling system is highly integrated with and dependent on other nations, and domestically, the regime varies between cities and other subnational jurisdictions. We therefore structured the boundary to be large enough to encompass the myriad regime components and dynamics, but not too large that detailed analysis was unobtainable. Our boundaries are therefore materially, geographically, and temporally based.

For our material boundary, in the U.S. plastics recycling system, materials often comprise mixed paper and cardboard, glass, metals, and plastics. We focus on plastics as they were arguably the material most impacted by Operation National Sword (Applied Research Foundation, 2019). For the geographic boundary, we focus on the impacts and solutions occurring in the U.S. and not internationally.

For the temporal boundary, the timeframe of this initial analysis is from 2016 – right before Operation National Sword was announced in 2017 – to early 2020. All pegged on Operation National Sword, this allows the historical “pre”, “in the moment”, and immediate “post” perspectives. Since this is within the past five years and the “post” perspective is ongoing, this is effectively a real-time analysis of that policy’s announcement as an avalanche change event. However, it is important to note that starting March 2020, the COVID-19 pandemic also affected the world, massively disrupting, and influencing all transition pathways. We therefore limit our analysis to before the COVID-19 pandemic began to tease apart Operation National Sword as a landscape influencer.

Next was determining the transition pathway. With the categorization of Operation National Sword as an avalanche change, we argue that the U.S. plastics recycling system was de-aligned in that avalanche change. By ‘de-alignment’ we mean that the U.S. plastics recycling system was suddenly and sizably disrupted by Operation National Sword, eroding the pre-existing regime. There were no sufficiently developed niche-innovations to fill that void. According to Geels and Schot (2007), a de-alignment without sufficiently developed niche-innovations means multiple niche-innovations will compete to fill the void left by the previous regime with only one niche-innovation ultimately taking that space. At that point, ‘re-alignment’ occurs with an entirely new regime. It is possible that the U.S. plastics recycling system currently has multiple niche-innovations competing to re-align the regime. However, we explore another option: that there are three emerging niche-innovations that will collectively form a new regime. This would be a sixth MLP transition pathway, also known as multiple new regimes.

To ensure our data were comprehensive, we leveraged an interpretive methodological approach (Thorn, 2020), and triangulated data from trade export sources (e.g., UN Comtrade Database), industry news sources (e.g., Waste Dive, Resource Recycling, Waste 360), policy developments and briefings (e.g., local, state, and federal bills and actions), NGO reports, and international developments (e.g., implemented trade regulations). We do acknowledge that our data and their sources have limitations and that not all perspectives, instances, and accounts were taken into consideration.

Below we describe how the U.S. plastics recycling system, pre-Operation National Sword, maps onto the MLP’s levels of niche-innovation, regime, and landscape. This step is important to demonstrate

how and why we argue the U.S. plastics recycling system is undergoing a de-alignment, followed by either a re-alignment or multiple new regimes.

4. “Ripe for a Reckoning” – the U.S. Plastics Recycling System

4.1 The U.S. Plastics Recycling System in the MLP

In terms of the U.S. plastics recycling system, niche-innovations include small-scale adjustments to improve recycling such as extended producer responsibility (EPR) and deposit-based legislation, technology for sorting materials, development of markets for post-consumer recycled content, and education to improve consumers’ waste sorting behavior. Furthermore, localized cultural and material options to prevent waste generation are manifesting as technologies, policies, and ideas (e.g., product repair workshops, plastic bag bans, and refill shops). Niche-innovations are not inherently norms, but they might help create new norms, or counter or amend existing norms.

The regime is the existing U.S. plastics recycling system. Figures 4.2a and 4.2b visualize the plastics flow of the U.S. system prior to Operation National Sword’s announcement in 2017. Figure 4.2a shows the flow when *recycling does occur*, meaning plastic materials are reclaimed and made into new products, and Figure 4.2b shows the flow when *recycling does not occur*, meaning plastic materials are disposed of, either domestically or internationally. This pre Operation National Sword U.S. plastics recycling system was mostly comprised of single stream recycling where consumers placed materials considered recyclable¹¹ for curbside collection or drop-off at the local recycling center, which included most, if not all, plastic resin types (the type of plastic, found in the numbers within a chasing arrows symbol). Once the plastics made it to the local recycling center they were sorted manually or with outdated or rudimentary technology. Plastics were then baled for shipment to facilities to ‘reclaim’ (break down and process) the material, and then be sold to manufacturers to make new products and goods. The facilities that reclaimed the plastic material were in China and other destinations. For years, this market structure was viable, benefitting enough stakeholders to perpetuate the operations and dynamics. Over time, however, due to the U.S. plastics recycling system’s negligence and China’s complacency, those bales became contaminated or were comprised of low quality material,¹² deeming them unfit for recycling and disposed of by the reclaimer (O’Neill, 2019). The governance of this plastics flow process is decentralized, in that cities and counties (known as local enforcement agencies (LEAs)) are the main implementors of waste management operations. LEAs must comply with state and federal regulations, which can be less prescriptive than local regulations.

¹¹ Materials are considered recyclable based on the contracts set up between local jurisdictions and the waste service provider, however, there is a wide range of what is considered “acceptable” recyclable material. These determinations occur on the local governmental level, so sometimes bordering towns can have very different recycling protocols (e.g., #5 plastic yogurt containers are or are not recyclable).

¹² Prior to Operation National Sword, the industry standard for categorizing material as “low quality” was by the ISRI Scrap Specifications Circular, grading A, B, C, and F for contamination levels by material type.

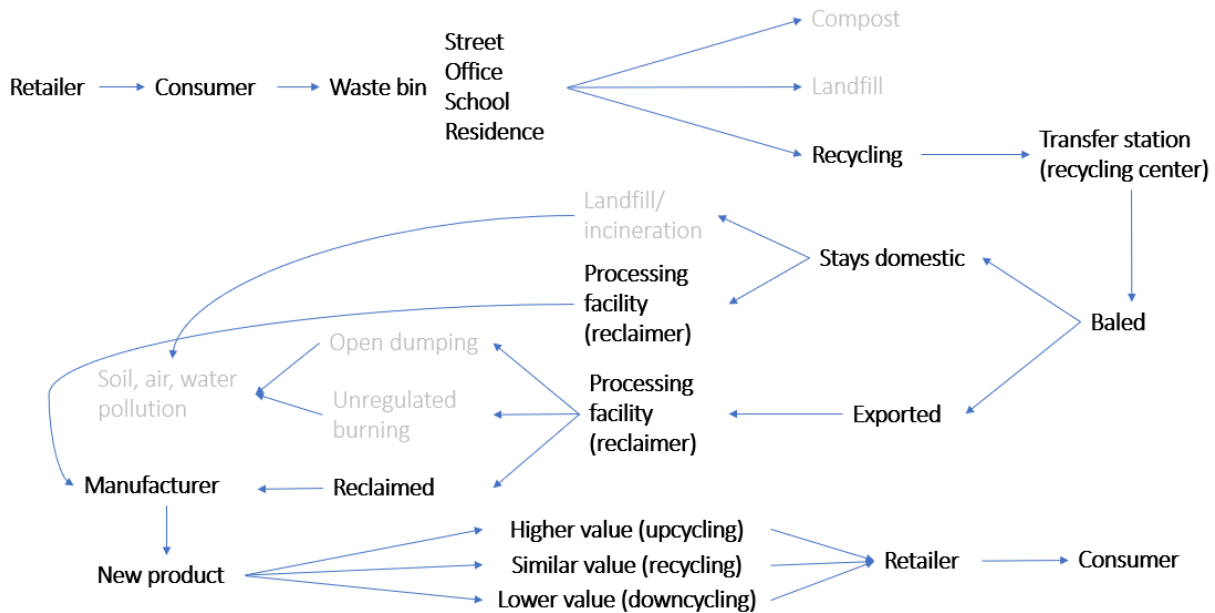


Figure 4.2a: The U.S. plastics recycling system's post-retailer plastics flow with recycling. In particular, this figure specifies the different available pathways and the intended pathway for plastics recycling, if recycling occurs. If recycling occurs, material is diverted from landfill and incineration because it has a market value and thus purchased by a processing facility (reclaimer).

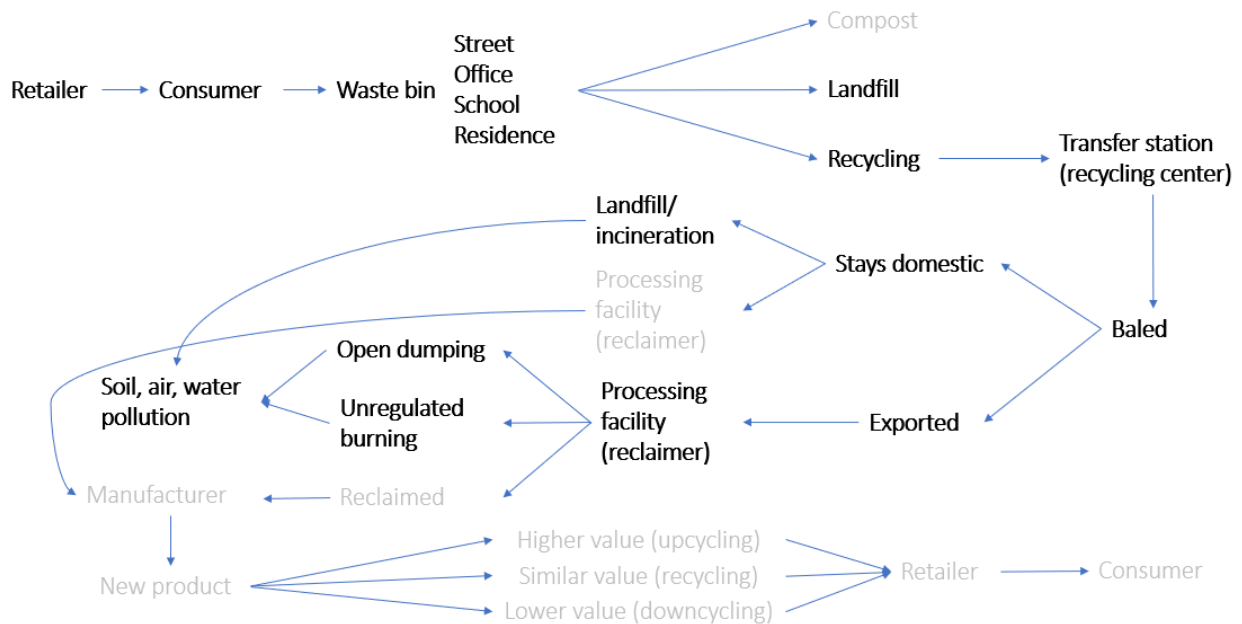


Figure 4.2b: The U.S. plastics recycling system's post-retailer plastics flow without recycling. In particular, this specifies the different available pathways and the intended pathway for plastics recycling, if recycling does not occur. Recycling does not occur because there is no purchaser for the material. This is often because the material is of low value or is contaminated. In these cases, material is landfilled or incinerated domestically, or it is exported and disposed of in other countries. That disposal can include open dumping and unregulated burning (Law et al., 2020).

The landscape is defined as the “exogenous environment beyond the direct influence of niche and regime actors” (Geels & Schot, 2007) (p.400). The landscape is thus the larger global recycling sociopolitical context. This includes what is happening in the import partners – China in particular, but also in other parts of Southeast Asia. It also includes bilateral agreements or international agreements such as the World Trade Organization (WTO) and The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Additionally, it includes the macroeconomics of trade, which dynamically determine recycling market prices domestically. For instance, if the global market price of a material drops, the costs to collect, sort, bale, and export the material can diminish the economic viability of such practices, thereby challenging local governments, waste service providers, and reclaimers (domestic or international) to attempt to recycle with very low profit margins. Finally, it includes large-scale, transnational organizations, movements, and policies, such as zero waste and the circular economy (Project Mainstream, 2016), and their counterparts, supporting business-as-usual practices through the linear (extractive) economy.

In keeping with the Geels and Schot (2007) MLP framework, below we discuss six regime components – also known as the recycling value chain (Cano et al., 2022) – of the U.S. plastics recycling system which demonstrate it was ripe for a reckoning. Included in those six regime components are empirical indicators of dysfunction that underscore the U.S. plastics recycling system’s lack of resilience. We then explain the waning of niche-innovations following the avalanche change, thus muddling the projections of whether the dominant regime will return to a single regime (re-alignment) or now include multiple, distinct regimes.

4.2 Regime Components and Indicators of Dysfunction

4.2.1 Policy (Decentralization)

An important and historical governance component of the U.S. plastics recycling system is its decentralized nature, especially in comparison with other countries. Authority over municipal solid waste (MSW) and recycling management varies by federal, state, and local jurisdictional level (Mouw et al., 2020). With thousands of individual services dispersed across the U.S., recycling governance was already arguably fractured and inefficient pre-Operation National Sword (Kaza et al., 2018). It is therefore not surprising that an immediate landscape shift (an avalanche change) would create chaos and instability in the low-resourced and unintegrated systems that did not have support structures to weather such abrupt and large-scale disruption.

4.2.2 Technology and Infrastructure (Contamination)

Contamination – material that is incorrectly put in a bale – is one of the largest barriers to plastics recycling (World Trade Organization, 2017). It is costly to sort out contaminants and contaminants reduce the viable end market opportunities for a bale because it reduces its quality and value. Contamination rates pre-Operation National Sword could be as high as 28% (Institute for Scrap Recycling Industries Inc., 2021) due to consumer sorting behavior, high operating costs to remove contaminants, and industry complacency over the years that tolerated high contamination rates. These highly contaminated bales of low value plastics were often dumped or burned in the importing country (Azoulay et al., 2019; Hamilton et al., 2019; Kaza et al., 2018). The prevalence of low value material made the U.S. plastics recycling system highly vulnerable to sudden changes in willingness by importers to accept this material.

4.2.3 Culture (Many Actors, Competing Interests)

The actors in the U.S. plastics recycling system are numerous, transboundary, and polarized. Main actors include retailers, consumers, waste service providers (e.g., waste hauler, MRF), intermediate processing centers, informal recycling sector workers (e.g., waste pickers), brokers, reclaimers, manufacturers, and disposal facilities (Figure 4.2). These actors are in the U.S. and in other countries. Additionally, domestic and international actors influence multiple steps along the recycling material flow, including legislatures (federal, state, and local governments), researchers, innovators, advocacy-based organizations, and reporters. These actors can have competing interests (e.g., threshold of acceptable bale contamination rates, threshold of transaction formality or informality), thus generating shifting power and relational dynamics. This complex system of diverse actors can result in divisions, especially when catastrophes occur, if they do not have a shared vision and aligned mental models (Senge, 1990). For example, actors can split over competing “zero waste” and “circular economy” ideas, both of which arguably seek the same goal – waste elimination – but differ in how to achieve that goal (Anshassi et al., 2019).¹³

4.2.4 Industry (Structure and Secrecy)

The U.S. plastics recycling industry is shrouded in secrecy, which erodes shock resiliency by hiding possible sources of compounded problems and areas for solutions. The public mostly does not know who the actors are, or the steps required to recycle a piece of plastic. They do not know where such processes occur, how long they take, or what sort of products their materials in their recycling bin might turn into. They also do not know the rate in which their recycling bin items actually turn into new products – in fact, they may not even realize their recycling can be futile. They may know their local waste service provider but that is it (Weber, 2019). The local government contracting with the waste service provider and the provider itself do not necessarily know all the actors involved from local collection to the end product (or fate if landfilled, dumped, or burned), and they certainly do not know where that is happening (Sheyner, 2021). An industry built on such lack of transparency and distancing with so many decentralized actors cannot swiftly react to sudden changes (Meadows, 2008; Princen, 2002). Furthermore, waste service providers have experienced heightened rates of consolidation in recent years as large, privately or publicly held companies are purchasing smaller, community-based operations (Rosengren, 2019, 2020a). This concentrated structure results in a few companies dominating the industry, thereby holding a high degree of market power, which includes controlling information and minimizing transparency.

4.2.5 Markets (Dependence on Exports to China)

The U.S. plastics recycling system had an undiversified market that was too reliant on China to purchase its scrap plastics. In the months after Operation National Sword, the scramble by the US (and other wealthy nations) to find other export markets (including Southeast Asian countries, Turkey, and others) underscored their failure to expand and diversify *domestic* markets for plastic scrap (Katz, 2019). This would not have been impossible: in the last year or two, there have been significant supply shortages of high-quality plastics to meet corporate goals of increasing secondary plastics use in soda bottles and other packaging. But it was made much more difficult by the outsourcing of manufacturing to China and other parts of the world as well.

¹³ Zero waste focuses on waste diversion-from-landfill rates, which prioritizes composting and recycling over landfilling (or incinerating) and the circular economy prioritizes retooling products to include byproducts (Anshassi et al., 2019).

4.2.6 Science and Engineering (Materials)

The material science aspect of recycling is complex, making the process of recycling exceedingly difficult for some materials, notably plastics. Mechanical recycling is the historical, and typical, form of recycling: materials go to a MRF, are sorted (by hand, by machine, or both), are cleaned, compressed, and baled to be shipped to the reclaimer. The reclaimer then further sorts, shreds, cleans, melts, extrudes, chops (into 'nurdles'), and bags as feedstock (base material) for manufacturers to create new goods and packaging (Romer, 2021). Of the plastic material in the U.S. that is considered recyclable, in 2015 only about 9% of it was recycled (Geyer et al., 2017). Most of that recycling occurred overseas (O'Neill, 2019). The science behind plastic recycling is thereby fraught with inefficiencies. So, even if the policy, technology and infrastructure, culture, industry, and markets all align for 100% capture of post-consumer plastic material, there would still be loss in what is truly recycled simply based on the scientific and engineering properties of the material.

5. The Impacts: Dealignment

Operation National Sword can be characterized as an avalanche change due to its rare occurrence, as well as its large-scale, wide-ranging, and immediate disruption. Its impacts began internationally in Spring 2018, a few months after Operation National Sword was implemented, however, some early warning signs beginning in 2017 had been noted (Rosengren et al., 2019). We delineate these itemized impacts and initial responses and their respective sources in *Supplemental Materials – Impacts of the U.S. Plastics Recycling System De-alignment*. We summarize the main points in this section.

Almost overnight, the trade of all major recyclable materials (glass, plastic, cardboard and mixed paper, and metal) was disrupted (O'Neill, 2019). In the matter of just a few months, some commodity prices plummeted (e.g., mixed paper went from \$66/ ton in 2016 to \$6/ ton in 2018 (U.S. EPA, 2020a)); MRFs' operating costs skyrocketed; and once lucrative – albeit volatile – materials became more expensive to collect, sort, and bale, with minimal-to-no market (Mouw et al., 2020) (also see *Supplemental Material – Market Prices for Plastics*). Service was therefore dramatically affected with providers switching to biweekly (or fewer) pickups, suspending service, reducing the hours or closing drop-off locations, and adjusting what materials they would accept (Rosengren et al., 2019). Mixed plastics (resin #3-7) were often the first recycling item with revoked acceptance, along with glass and some paper types. In both curbside services and drop-off locations, waste service providers increased their service rates to cover the higher processing costs and worse market conditions. They also levied more contamination fees on residential customers using their services, which was a stipulation in their contract, but not often enacted. Some even went as far as discontinuing service for repeat contamination offenders. Contracts negotiated with local governments on the assumption that cheap exports to China would continue, often in place for 10 to 15 years, were suddenly straining both waste service providers and local governments, resulting in costly and tenuous renegotiations or even cancellations (Rosengren, 2020b). The economics between service fees, operation costs, contract stipulations, and market prices created a collapse of recycling viability for providers and local governments.

Cities and counties saw higher rates of illegal dumping. Trying to clean up this dumping and supporting the waste service provider in their lost income or covering the contamination fees imposed by importing countries resulted in higher costs to municipalities (Mouw et al., 2020), often coming from their Public Works or reserve budgets. Additionally, typically in a waste service provider contract, the

municipality receives some of the revenue the provider gains in material transactions, and since there were no market gains, municipalities were also not receiving those funds.

As a result, plastics were stockpiled in warehouses and open lots or disposed in landfills and incinerators. The material stockpiled was done optimistically to wait out the initial volatility post implementation of Operation National Sword (Albeck-Ripka, 2018). Once MRFs and storage spaces overflowed with stockpiled plastic bales, providers moved them to landfills and incinerators as it was cheaper to dispose of them than to pay for additional storage space (Roston, 2019).

6. The Solutions: Immediate Response

The solutions are proactive actions taken to remedy the disruption caused by Operation National Sword after the impacts were noticed. These actions occurred intermittently and not across all jurisdictions. Most solutions launched in Summer and Fall of 2018. Itemized solutions and their respective sources are in *Supplemental Materials – Solutions of the U.S. Plastics Recycling System De-alignment*.

There were no systematic, coordinated solutions beyond the local level; most were ad hoc and location specific. This was in part due to the U.S. EPA under the Trump administration not exercising broader policy and regulatory oversight as it did under other administrations (Sullivan et al., 2021). However, a solution commonly seen in many jurisdictions, but with varied messaging and implementation, was educating residents on proper waste sorting and recycling practices (Rosengren et al., 2019). Jurisdictions belatedly began framing recycling as a privilege and not a right, thereby putting more onus on individual residents to produce less contaminated materials.

Some local solutions managed by waste service providers were infrastructural changes such as implementing dual stream collection bins (one bin for plastics and metals, a separate bin for paper and cardboard), so customers pre-sorted their cans and bottles from their mixed paper and cardboard to create cleaner recycling streams (Rosengren et al., 2019). Some municipalities formed regional recycling partnerships in response to waste service providers consolidating and implementing conglomerate rate increases. These partnerships also allowed different materials to be aggregated and allocated to different jurisdictions (e.g., one jurisdiction agreeing to take others' plastics) to keep services open longer (Rosengren et al., 2019). A few municipalities also implemented reporting requirements to better track material flow, recycling rates, and costs as well as multistakeholder taskforces to create more unity across the myriad actors (Rosengren et al., 2019).

New non-mechanical recycling processes are also gaining traction. These are transformational technologies, an umbrella term for technologies that purify, decompose, and convert used plastics into like-new materials (feedstock) such as pyrolysis, gasification, and hydrothermal treatment (Thiounn & Smith, 2020). In that process, however, they also create chemicals and fuels (energy). The recycling efficacy rate is therefore unclear, especially as these technologies remain nascent. In fact, the Global Alliance for Incinerator Alternatives (GAIA) categorizes transformational technologies as a veiled incineration and thus disposal method (GAIA, 2019).

Interestingly, there was a drop in new technological and infrastructural or scientific and engineering niche-innovations around Operation National Sword (see Appendix D). MLP transition pathway assumptions would predict the immediate development of myriad niche-innovation solutions to steady the disruption from the avalanche change. It is hard to quantify such niche-innovations

because of they are inherently localized, sometimes informal, or written off as profit loss from internal research and development. The lack of such siloed technological and niche-innovations developing demonstrates that the U.S. plastics recycling system is not undergoing a technological change (no niche-innovations were mature to successfully assume regime dominance), or a transformation pathway (no niche-innovations are developing as a response to the disruption).

We do see a rise in ‘subnational’ (niche-innovation) policies that reduce dependence on recycling (e.g., banning plastic bags, put a fee on disposable foodware), with 6 in 2017, 12 in 2018, 15 in 2019, and 2 in 2020 (Karasik et al., 2020b) (see Appendix E). Furthermore, we see a large wave of consolidation among waste service providers. This is, in part, due to corporate tax cuts in 2017 making such acquisitions more financially viable (Rosengren, 2020a). However, trend of Big Waste purchasing smaller companies is likely also due to waste service providers opportunistically expanding amid the disrupted U.S. plastics recycling system by providing alternative services (e.g., waste disposal). These policy and industry niche-innovations, we argue, are not independent niche-innovations, but instead coincide with three larger emerging trends described in the following section.

7. What is Next? A Re-Alignment or Multiple New Regimes?

The de-alignment of the U.S. plastics recycling system regime is quite evident, as described earlier, based on myriad factors and effects caused by the Operation National Sword avalanche change. However, it is less clear what will happen next. In this section we offer analytically based forecasts based on our arguments so far.

There was no well-developed set of niche-innovations that could immediately add to or replace the U.S. plastics recycling system. Its de-alignment left a void, as demonstrated by the frantic, scatter-shot solution-finding. If the system is to follow a re-alignment transition pathway, according to the MLP framework, a new, single niche-innovation will become dominant, “forming the core for re-alignment of a new regime” (Geels & Schot, 2007). With numerous solutions being tried out, such an unequivocal winner is not yet present nor apparently emerging. Instead, it appears a few niche-innovations are rising, thereby possibly forming multiple co-existing facets of a new U.S. plastics recycling system regime or, potentially, co-existing regimes. We identify three new facets – *zero waste and circular economy movements*, *domestic processing*, and *eliminating problematic plastics* (as shown in Figure 4.3) – that are highly divergent in their desired regime state: waste elimination, more socially and environmentally healthful recycling practices, and a more stable and viable recycling system.

The zero waste and circular economy movements, while they differ in their steps to accomplish waste elimination, both lean into recycling but abhor the inefficiencies of preexisting recycling practices (Enck & Dell, 2022). These movements advocate upstream regulation – before the product is made or consumed – to decrease the prevalence of waste material, even if it is recyclable. They acknowledge the importance of recycling – but only upcycling (into a higher valued product) and recycling (into a similarly valued product), not downcycling (into a lower valued product) – to achieve a waste-free vision. Their stance is that recycling must occur and must do so at higher recycling utilization rates than 9% (#breakfreefromplastic, n.d.; Basel Action Network, n.d.-a; Ellen MacArthur Foundation, n.d.-b; GAIA, n.d.; U.S. Plastics Pact, 2020). These movements are gaining traction through supportive local and state legislation to make recycling processes more transparent (Gonzalez, 2021; Sheyner, 2021); technological advances in service-based (versus ownership-based) models (Ellen MacArthur Foundation, n.d.-a); infrastructure that supports reusables and refillables (Container Recycling Institute, 2021; Maienschein,

2022; The Coca-Cola Company, 2022; Unilever, 2019); and advocacy for the right to repair personal goods (Paul, 2021). The movements' objective is the elimination of waste generation.

Domestic processing entails a shift towards retaining all recycling materials domestically and reclaimers and manufacturers processing them in domestic plants. The theory of change is that if we refrain from distancing the social and environmental harms associated with our pre-existing recycling practices, we will engage in more socially and environmentally healthful recycling practices (Princen, 2002; Worthy, 2013). Part of this shift was forced on the U.S. through Operation National Sword to keep more material domestic, but the other part is continuing the shift towards purposeful increases in investment and innovation in domestic recycling practices by investors, waste service providers, and governments (Rosengren, 2019, 2020b). This includes funding secondary sorting technology development to capture more MRF residuals for sale (Rosengren, 2020c; Titus MRF Services, 2020); funding other waste sorting technology like optical sorting to capture more high-quality plastics (Barker, 2021; Pyzyk, 2019); and opening more redemption centers which generate higher quality, pre-sorted recyclable plastics (Tucker, 2019). The result would be less international plastic waste and scrap trade and therefore more socially and environmentally sound practices domestically. However, it is critical to assess that investments do follow those guidelines. Such assessment is emerging at the local level with governments writing strict stipulations of transparency and end-market conditions into their contracts with waste service providers (Sheyner, 2019). Additional assessments will occur at the state or federal level due to recent and pending legislation (Quinn & Rosengren, 2022; Waste Dive Team, 2021). Domestic processing's objectives are less mismanagement (open dumping and burning) of plastics and less social and environmental harm caused by the current use and processing of plastics.

The final divergent facet of the pre-existing recycling practice is reducing problematic plastics. This advocacy and practitioner push aims to reduce the types of plastics in use so those captured in recycling streams have a higher rate of being recycled. This includes more bio-based plastics (e.g., compostable plastics) (Ellen MacArthur Foundation, n.d.-b); mostly using plastics #1 and #2 as they have a higher, more reliant market (U.S. Plastics Pact, 2022); building more of a domestic market for post-consumer recycled content in products (Basel Action Network, n.d.-a); and redesigning products so components are more modular and can be separated to be processed differently (Ellen MacArthur Foundation, n.d.-a, n.d.-b). This would reach the objective of a recycling system that accepts fewer plastic resins – and therefore less contamination – but has a higher value and larger market for those recycled plastics, thereby creating a more stable and viable recycling system.

As we write (2022), the U.S. federal legislation progress to support the U.S. plastics recycling system is slow, encouraging, and multi-dimensional. It is slow in that few bills have passed the House and Senate in recent history, except for Save Our Seas 2.0 (Sullivan, 2020) and the Infrastructure Investment and Jobs Act (DeFazio, 2021) which includes text from the RECYCLE Act (annual recycling education grants of \$15 million per year for five years). The U.S. Environmental Protection Agency (EPA) announced a non-legally binding recycling goal of 50% by 2030 (U.S. EPA, 2020c) as well as its first-ever federal recycling strategy (U.S. EPA, 2021a). It is encouraging because there are 19 bills in various stages of congressional consideration (Quinn & Rosengren, 2022), a number that far exceeds the handful of bills introduced in the 2010s (Wagner, 2016, 2017). And it is multi-dimensional because the bills span from program development (Zero Waste Act) to infrastructure (Recycling Infrastructure and Accessibility Act) and system change (Break Free From Plastic Pollution Act). They also focus on specific materials or settings such as compost (COMPOST Act), schools (School Food Recovery Act), or electric vehicles (Strategic EV Management Act). What happens in terms of federal legislation around plastics recycling –

which measures do or do not get adopted (if any at all) will likely shape how the ways in which regime facets dominate, fracture, or co-exist.

Globally, discussions and actions are now shifting towards addressing the social and environmental harms of plastic waste generation, trade, and disposal with three recent landscape changes. In the past two years, The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted the plastics amendment (January 1st, 2021) which restricts shipping plastic scrap that are ‘mixed plastics’ (resin number 3-7) and prohibits shipping plastic that has than one plastic resin type or is otherwise contaminated (e.g., food residue, metals, paper/fiber) (U.S. EPA, 2021b). The second change is the United Nations Environment Assembly agreed to begin negotiations on a global treaty to tackle plastics. The resolution for the legally-binding treaty aims to co-develop a framework incorporating stakeholders from industry to affected populations, incorporating innovative waste reduction strategies from production to disposal, all the while emphasizing circularity (UNEA of the UN Environment Programme, 2022). Negotiations are planned for 2022 with the international negotiating committee detailing their plan in 2024. The third landscape development is the United Nations General Assembly declaring it is a human right to have access to a clean, healthy, and sustainable environment (UN News, 2022). This non-legally binding declaration took five decades to become a resolution. One of the three interlinked environmental issues it emphasizes is pollution, a byproduct of plastic production and disposal.

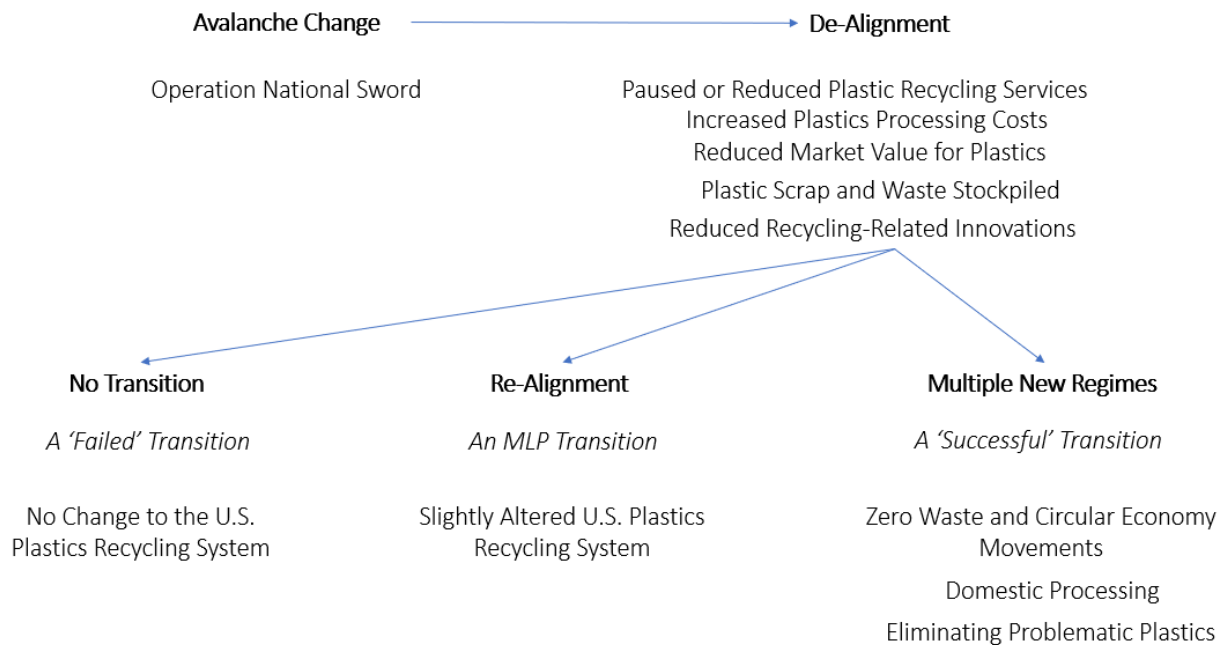


Figure 4.3: The three potential MLP transition pathways (no transition, re-alignment, or multiple new regimes) of the U.S. plastics recycling system.

8. Conclusions and Recommendations

8.1 The Framework: The Reckoning and the Transition

We argue that Operation National Sword, as an avalanche change, catalyzed a reckoning (a de-alignment) in the U.S. plastics recycling system and that the regime is in the middle of an emerging transition. Pre-Operation National Sword, the U.S. plastics recycling system had incremental development from winners winning and securing their hold on the system (e.g., adding more product types to what is considered recyclable). This was instead of methodical adaptations for more environmentally and socially healthful practices (e.g., not accepting previously accepted materials because they no longer had a viable market for proper recycling management). These regime components included policy (decentralization), technology and infrastructure (high contamination of waste), culture (actors), industry (secrecy), markets (dependence on China), and science & engineering (materials). The impacts (reactions) and solutions (actions) that the regime actors are taking post-Operation National Sword do not clearly demonstrate if a niche-innovation will assume regime domination for a re-alignment or if several niche-innovations will result in multiple new regimes.

The U.S. plastics recycling system had a long-standing stasis with occasional incremental changes of varying sizes that altered its features, (e.g., the adoption and proliferation of curbside recycling, deposit schemes, and plastic collection, plus exporting material, and now international policy influencing waste trade). It was then interrupted by an avalanche change, coupled with the development of the zero waste and circular economy movements, domestic processing, and eliminating problematic plastics. We therefore posit that the U.S. plastics recycling transition is following a pathway more akin to Eldredge and Gould’s (1972) punctuated equilibrium – multiple new regimes – than Geels and Schot’s (2007) five transition pathways.

8.2 Transition Completion and Success?

Apart from assessing and applying a theory used to analyze transitions – the MLP framework – we are also interested in questions concerning if the transition is complete, and if it is a ‘success.’ For this transition to be unequivocally confirmed as a ‘success’ compared to a ‘failure’ (Wilson, 2007), ‘success’ must be clearly defined and more time must pass in order to have that retroactive versus real-time perspective.

Presently, it is unclear if the U.S. plastics recycling system is headed towards a ‘successful’ transition as opposed to a ‘failed’ transition where no transition occurs, and a stagnant and/or harmful system perpetuates. This is further complicated by the impacts of the COVID-19 pandemic on initiatives to reduce single-use plastics, and on the recycling industry itself (Heiges & O’Neill, 2020). The system continues to generate unreclaimable plastic (waste) at increased rates as well as export that material to countries with high plastic mismanagement rates (Basel Action Network, n.d.-b; Law et al., 2020). The solutions implemented due to Operation National Sword are progressing towards both a re-alignment and multiple new regimes right now. Table 4.1 presents a few of our thoughts on what a more sustainable, just, and methodical regime state might look like, defined through the United Nations General Assembly’s global human right to a clean, healthy, and sustainable environment. Our thoughts integrate all three emerging niche-innovations of zero waste and circular economy movements, domestic processing, and eliminating problematic plastics.

Sociotechnical Regime Dimensions and Possible Changes for a More Sustainable and Just U.S. Plastics Recycling System

Policy

Implement local, state, and federal bans and taxes on problematic plastics

The U.S. becomes a signatory to the Basel Convention’s plastics amendments

<i>Technology and Infrastructure</i>
Only materials that can be effectively recycled (given science & engineering) will be collected as recycling in local jurisdictions across the U.S.
More efficient collecting, sorting, and baling of materials at recycling centers ¹⁴
<i>Culture</i>
Less reliance on disposable products
Higher rates of properly sorted materials
<i>Industry</i>
Greater transparency around end destination and fate of recycled plastics
More centralization of recycling policy and procedures, which could include standardization of materials accepted, or state-level or nationwide bans and taxes
<i>Markets</i>
Diversification of export recipients
Material exported from the U.S. will be reclaimed and not mismanaged or disposed
A stronger and more competitive reclamation market, including in the U.S.
More demand for recycled content feedstock
<i>Science</i>
New product designs that are easier to reclaim (e.g., have modular components)
Product and packaging materials will be easier to recycle (e.g., made with fewer materials, made with materials that have a stronger reclamation probability, are easier to deconstruct for recycling processes)

Table 4.1: Proposed solutions to achieve a more sustainable, just, and methodical U.S. plastics recycling system.

We recommend future research to better understand the three developing niche-innovations and their emerging interactions, complexities, co-existence, and paths towards legitimization and stability. Once the transition is ‘complete’, which will take years, if not decades (Köhler et al., 2019), it will be crucial to do more analyses of the impact of Operation National Sword on the U.S. plastics recycling system. An analysis at that time, with the MLP framework, will help better understand if our untraditional, real-time analysis application is a viable means to interpret concurrent events, if updates to that type of methodological analysis are needed, or if the MLP and its preexisting structure should only be used through post hoc historical analysis. It will also inform us if multiple new regimes as a refinement to the framework is a needed sixth pathway.

Supplemental Material

Table S.4.1 Impacts of the U.S. Plastics Recycling System De-Alignment

The impacts on the U.S. plastics recycling system regime, by regime dimensions, immediately after Operation National Sword was announced (late 2017 – early 2020).

Sociotechnical Regime Dimensions and Changes	Impacts	Citations
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¹⁴ Recycling centers include materials recovery facilities (MRFs) and intermediate processing facilities such as redemption centers.

Markets, user preferences

The commodity price of tradeable recycled commodities	Decreased	(Recycling Markets, 2021; U.S. EPA, 2020a)
The price of virgin material	Crude oil: volatile (\$126, \$179, \$126, \$160, \$135) Aluminum: relatively stable (\$2.1-2.3k) then down (\$1.7k) Metals: relatively stable (\$76-83) Wood pulp/ paper: volatile (\$744, 709, 750, 778) Soda ash/ glass: same	(Mundi, 2021; USGS, 2020) (p. 152)
The cost of landfill tipping fees	Increased (1.1%-5.6% between 2016 and 2020)	(EREF, 2021)
The cost of recycling services to residential and corporate clients	Increased	(Rosengren et al., 2019)
The number of independent MRFs	Decreased	(Rosengren et al., 2019)
Big Waste's stock price ^a	<i>Prices are Oct '17, '18, '19</i> Clean Harbors: \$51, 62, 78 Covanta: \$15, 16, 17 WM: \$76, \$90, \$111 Republic Services: \$64, 72, 86 Waste Connections: \$69, 77, 94	(Clean Harbors Inc., 2021; Covanta Holding Corp., 2021; Republic Services Inc., 2021; Waste Connections Inc., 2021; Waste Management Inc., 2021)
The profit realized by MRFs and local governments for recycling services	Decreased	(Rosengren et al., 2019)
The cost of MRF operations	Increased	(Rosengren et al., 2019)
<i>Culture</i>		
The amount of public awareness of the waste generation and disposal problem	Increased	(Google Trends, 2021)

Science

The number of patents that focus on the reduction or elimination of waste	Decreased	Google Patents – see <i>Supplemental Material Table S.4.4</i>
<i>Technology</i>		
The number of startups that focus on the reduction or elimination of waste	Decreased	Crunch Base – see <i>Supplemental Material Table S.4.4</i>
The number of mergers and acquisitions to scale nascent technologies (as opposed to Big Waste consolidation)	Increased	(Valentic, 2020)
<i>Industry</i>		
The number of mid-contract renegotiations or early terminated contracts	Increased	(Rosengren et al., 2019)
The types of materials accepted by recycling services	Decreased	(Rosengren et al., 2019)
The number of curbside services offered	Decreased	(Rosengren et al., 2019)
The number of recycling drop-off locations	Decreased	(Rosengren et al., 2019)
The number of pilots conducted by recyclers (e.g., dual stream, bin tagging, secondary sorting)	Decreased	(Rosengren et al., 2019)
<i>Policy</i>		
The number of import policies that restrict the type of material accepted	Increased	(CalRecycle, 2021)
The number of proposed or enacted single-use goods production reduction or elimination policies, locally, nationally, regionally, and internationally (upstream)	Decreased	(Rosengren et al., 2019)

The number of proposed or enacted recycling policies, locally, nationally, regionally, and internationally (downstream)	Decreased	(Rosengren et al., 2019)
The number of paused or vetoed plastic and glass reduction policies	Increased	(Rosengren et al., 2019; Zero Waste Lab, 2020)
The number of enforcement citations due to non-compliance	Increased	(Rosengren et al., 2019)

Plastic Scrap Trade and Recycling Data

The total amount of waste generated	Increased	(U.S. EPA, 2020c)
The amount of recyclable scrap being generated	Increased	(U.S. EPA, 2020c)
The amount of recyclable scrap in natural systems, littered or leaked	Increased ^b	(Law et al., 2020; U.S. EPA, 2020c)
The amount of recyclable scrap in landfill or incineration	Increased	(Rosengren et al., 2019)
The amount of recyclable scrap going to countries with inadequate waste management facilities	Decreased	(CalRecycle, 2021)
The average contamination rate of bales exported for recycling purposes	Decreased	(Waldrop, 2020)
The amount of material stockpiled domestically	Increased	(Albeck-Ripka, 2018)

^a Of the ten largest waste management companies in the world, we selected the five companies that are traded on the New York Stock Exchange.

^b There are no statistics on the U.S. litter rate over the years. In 2020, Law et al. published an article which stated that high-income countries had a litter rate of roughly 2% of the country's waste

generation. If we assume that 2% litter rate remained stable post announcement of Operation National Sword, then the total tonnage of litter increased along with the total tonnage of waste generated since Summer 2017 (pre-Operation National Sword).

Table S.4.2 Solutions of the U.S. Plastics Recycling System De-Alignment

Actions taken by the U.S. plastics recycling system regime to improve conditions post-Operation National Sword (earliest recorded action is late 2018, then analysis goes through early 2020).

Sociotechnical Regime Dimensions and Changes	Solutions	Citations
<i>Markets, user preferences</i>		
Formation of regional recycling partnerships to counter Big Waste’s conglomerate rate increases	Increased	(Rosengren et al., 2019)
Expand education campaigns to reduce at-bin contamination by consumers	Increased	(Rosengren et al., 2019)
Minimal funding from chemical and gas/oil companies to improve local recycling infrastructure and services (e.g., extended operating hours)	Increased	(Rosengren et al., 2019)
<i>Industry</i>		
The number of domestic reclaimers	Increased	(NERC-NEWMOA Regional Recycling Markets Committee, 2020)
Removal of glass, mixed plastics, and paper from accepted items	Increased	(Rosengren et al., 2019)
The number and/or strength of domestic partnerships	Increased	(Rosengren et al., 2019)
Discontinued services for repeat residential or commercial offenders	Increased	(Rosengren et al., 2019)
The sharing of learnings and solutions across municipalities	Increased	(Rosengren et al., 2019)
The use of secondary sorting	Increased	(Rosengren et al., 2019)

The number of pilots conducted by recyclers (e.g., dual stream, bin tagging, secondary sorting)	Increased	(Rosengren et al., 2019)
<i>Policy</i>		
Actions and acknowledgements from Governors and Mayors to address the “recycling crisis”	Increased	(Rosengren et al., 2019)

Table S.4.3 Market Prices for Plastics

Market prices for different plastic commodities between July 2016 to February 2020, broken out by month. The columns are conditionally formatted, with dark grey indicating higher prices (within that plastic type – column). These data were obtained from Recycling Markets (2021).

	Plastics Commingled (#1-7, Baled, ¢/lb., picked up)	Plastics PET (Baled, ¢/lb., picked up)	Plastics Natural HDPE (Baled, ¢/lb., picked up)	Plastics Colored HDPE (Baled, ¢/lb., picked up)
Date	National Average	National Average	National Average	National Average
February 2020	\$2.18	\$10.03	\$48.71	\$7.99
January 2020	\$2.19	\$9.99	\$59.66	\$12.31
December 2019	\$2.19	\$10.34	\$58.96	\$14.61
November 2019	\$2.19	\$9.51	\$53.34	\$14.39
October 2019	\$2.19	\$9.67	\$45.47	\$12.79
September 2019	\$2.19	\$10.52	\$29.62	\$10.56
August 2019	\$2.19	\$13.08	\$22.53	\$9.98
July 2019	\$2.19	\$14.73	\$20.50	\$11.36
June 2019	\$2.19	\$15.16	\$20.70	\$12.54
May 2019	\$2.19	\$15.45	\$20.82	\$13.66
April 2019	\$2.19	\$15.50	\$21.35	\$13.63
March 2019	\$2.19	\$15.05	\$26.35	\$14.28
February 2019	\$2.22	\$15.08	\$35.16	\$14.97
January 2019	\$2.25	\$15.10	\$38.53	\$16.33
December 2018	\$2.25	\$15.02	\$38.76	\$16.65
November 2018	\$2.25	\$15.04	\$38.88	\$15.94
October 2018	\$2.25	\$15.29	\$38.25	\$14.07
September 2018	\$2.25	\$16.03	\$38.25	\$13.69
August 2018	\$2.28	\$16.68	\$38.69	\$14.30
July 2018	\$2.38	\$16.92	\$38.81	\$14.58
June 2018	\$2.38	\$17.01	\$37.78	\$14.24

May 2018	\$2.19	\$15.45	\$20.82	\$13.66
April 2018	\$2.36	\$15.32	\$35.68	\$18.04
March 2018	\$2.37	\$14.43	\$35.15	\$16.79
February 2018	\$2.44	\$13.93	\$31.84	\$15.30
January 2018	\$2.44	\$13.80	\$30.00	\$15.01
December 2017	\$2.44	\$13.58	\$30.13	\$15.59
November 2017	\$2.44	\$14.04	\$30.06	\$16.83
October 2017	\$2.44	\$14.99	\$29.92	\$16.26
September 2017	\$2.47	\$15.58	\$29.12	\$14.87
August 2017	\$2.50	\$15.66	\$27.25	\$13.88
July 2017	\$2.50	\$15.72	\$27.07	\$14.01
June 2017	\$2.49	\$15.55	\$26.47	\$13.11
May 2017	\$2.44	\$14.61	\$28.57	\$14.59
April 2017	\$2.50	\$15.66	\$27.25	\$13.88
March 2017	\$2.44	\$13.13	\$31.44	\$21.21
February 2017	\$2.44	\$11.84	\$26.50	\$16.60
January 2017	\$2.44	\$11.10	\$24.32	\$13.91
December 2016	\$2.44	\$10.47	\$23.25	\$13.17
November 2016	\$2.43	\$10.05	\$25.51	\$19.03
October 2016	\$2.38	\$10.15	\$27.15	\$21.12
September 2016	\$2.45	\$10.50	\$26.00	\$17.22
August 2016	\$2.50	\$10.87	\$29.29	\$15.15
July 2016	\$2.67	\$11.18	\$34.83	\$16.10

Table S.4.4 Technological and Infrastructural or Scientific and Engineering Niche-Innovations

The table below demonstrates the drop in new technological and infrastructural or scientific and engineering niche-innovations during the disruption caused by Operation National Sword. The trends are of new startups (CrunchBase.com) and patents (patents.google.com) from 2015 through 2020. Please note that “waste” and “closed loop” were not assessed for patents as those two terms are decidedly not specific to the recycling and waste management industries, thereby capturing superfluous and irrelevant data (e.g., closed loop electrical systems or wastewater systems).

Database	CrunchBase						Patents.google.com				
	“waste”	“recycling”	“circular economy”	“zero waste”	“closed loop”	“waste management”	“waste management”	“recycling”	“zero waste”	“circular economy”	
2015	322	115	16	9	17	102	70,660	24,885	41,686	7,296	
2016	315	104	19	4	10	91	72,515	21,673	41,553	7,388	
2017	296	95	23	12	8	88	70,778	17,614	39,806	6,740	
2018	273	92	25	12	14	84	62,727	11,381	34,495	5,833	

2019	195	66	25	15	4	69	45,110	5,802	24,236	3,914
2020	87	31	11	4	3	27	18,695	294	10,000	1,867

Table S.4.5 Policy Niche-Innovations

Below is a table of the ‘subnational’ (niche-innovation) policies enacted in the U.S. between 2015 and 2020 that reduce dependence on recycling. These policies, specific plastic reduction, elimination, and management, invoke numerous policy mechanisms. Data for this table came from the Plastic Policy Inventory Search, managed by members of Duke University’s Nicholas Institute for Environmental Policy Solutions (Karasik et al., 2020b).

Year	Number of Subnational Policies Reducing Reliance on the U.S. Plastics Recycling System
2015	3
2016	5
2017	6
2018	12
2019	15
2020	2

Chapter 5

Preventing the Influx of Waste in Future Disasters: Reflecting on COVID-19

This chapter was included here with permission from co-authors

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Abstract

COVID-19 is a worldwide disaster that has upended many sustainability transitions. One such transition was the emerging movement away from single use disposable (SUD) materials. Not only did COVID-19 disrupt that transition, but a waste category was redefined as a result: hygiene waste, which is the waste material generated from promoting or maintaining hygiene, most notably within the healthcare and foodware sectors. Hygiene waste was generated globally; however, we focus on the U.S. to better understand the base conditions – policies, actors, and drivers – that contributed to the large hygiene waste tonnage. This quick rise in hygiene waste in the U.S. came from decisions made by three actor groups: governments and agencies, industries, and consumers. Those decisions affected processes, categorizations, technologies, and policies that in turn directly or indirectly influenced hygiene waste generation. To harden the anti-SUDs transition to future macro-level disruptions and disasters, we recommend actor-oriented changes that promote hygiene waste preparedness, decrease influence from vested interests, and expand upstream anti-SUD practices. Further, we recommend policy changes that create a more robust mix of anti-SUD healthcare and foodware policies and integrate such policies into the Health in All Policies (HiAP) initiative.

1. Waste in the Time of a Pandemic

1.1. Disaster Waste

The COVID-19 pandemic is a global disaster. A disaster arises from vulnerability coupled with an event, resulting in significant disruption of the social order and negative consequences (Perry, 2007). That vulnerability includes underlying causes (e.g., poverty), dynamic pressure (e.g., lack of institutional support), and unsafe conditions (e.g., geographic location) (Kwakkel et al., 2013). The event can be natural disasters (e.g., fires and tsunamis) or social disasters (e.g., terrorism and pandemics). It can be sudden (e.g., earthquakes and lightning strikes) or slowly developing (e.g., drought and civil unrest) (Brown et al., 2011). For COVID-19, large systematic vulnerabilities combined with a sudden, highly contagious novel virus resulted in pervasive global disruption and millions of deaths and long-term disabilities.

Disasters create waste. “Disaster waste” includes the destroyed utility equipment from a tornado, the rubble from an earthquake, the ready-made-meals for displaced persons, the medical supplies needed for recovery, or the inherent waste in unplanned, fear-based purchases (O'Neill, 2019). Innumerable aid organizations, disaster preparedness plans, and emergency response teams focus on mitigating the harm of disasters and create humanitarian support during and after the disaster. They do not, however, include strategies for harm mitigation, reduction, or prevention for disaster-related waste (O'Neill, 2022). COVID-19 resulted in unprecedented levels of disaster waste (Hantoko et al., 2021).

Two types of waste are new to this category of “disaster waste,” and were not coupled until the COVID-19 pandemic: single use disposable (SUD) healthcare and foodware waste. We use the umbrella

term “hygiene waste” to delineate waste generated by products designed to protect individual health across multiple settings. So far, these two categories of SUD hygiene waste have rarely been coupled. This is not surprising because 1) while healthcare and foodware each faced pressures to reduce reliance on SUDs before the pandemic, they did not have overlapping visions, actors, or strategies (Heiges, n.d.; Practice Greenhealth, 2023); 2) in previous health crises, SUD plastics did not have the advanced development and proliferation across sectors including a stronghold on the perception of hygiene; and 3) COVID-19 was unprecedented in its scale, severity, and speed of transmission thereby abruptly generating SUD wastes at far higher rates and amounts. This paper examines hygiene waste as one of COVID-19’s chief environmental impacts. The environmental impacts were not only waste generation, but – upstream – undermining hard-won victories to curb SUD waste, and – downstream – overburdening waste disposal and recycling infrastructure. However, the proliferation of hygiene waste during COVID-19 has brought healthcare waste into focus, which was not the case before COVID-19.

We add to the growing literature on COVID-19 wastes, including the categorization and examination of hygiene waste. Further, we provide lenses through policies and actors to learn why and how actions were taken and how policies and procedures can prevent the proliferation of hygiene waste in future disasters.

COVID-19 hygiene waste is a global phenomenon. However, in this study, we focus on U.S. policies, actors, and drivers as they relate to hygiene waste. This detailed examination into the U.S. conditions is meant to help better understand, and thus curb, the emerging and additive harm of hygiene waste to the harms already inherent in disasters. We focus on the U.S. because that is the system we know best and have the most data for. However, while this paper is centered on the U.S., we do draw on relevant data from other nations. We hope our case study can provide insight and support to other geographies grappling with the same issue, even if their base conditions of policies, actors, and drivers are different than that in the U.S.

1.2. What is Hygiene Waste?

Prior to COVID-19, “hygiene waste” was more closely aligned with biomedical waste, menstrual hygiene, or household medical waste (Chand et al., 2020; Elledge et al., 2018). Numerous articles that examined the new and different waste streams generated by COVID-19 mention the rise of both SUD healthcare and foodware waste but they do not combine the two, nor analyze their correlated growth, and expansion beyond hospitals and medical facilities into the household waste sector (Hantoko et al., 2021; Mittal et al., 2022; Yousefi et al., 2021). We are therefore building on those works by combining them to foster the development of a new research field: disaster-related hygiene waste.

Hygiene products – the items that result in hygiene waste – are those associated with maintaining health and preventing disease, with a special focus on cleanliness. Health-related hygiene products include healthcare items (e.g., bandages, swabs, syringes), personal protective equipment (PPE) (e.g., masks, gloves). Food-related hygiene products include certain kinds of food and beverage containers and accessories (e.g., cups, lids, utensils). Such products can be reusable or SUD. SUD means that it fulfills its intended single use, then is disposed of. Hygiene products are used at healthcare facilities, retailers, other public or private facilities, and by individuals. In all cases, the use of hygiene products is to prevent infection and the spread of disease (CDC, 2022b), because it is mandated (DIR, 2022), or for the appearance of being hygienic (Thompson, 2020). Our focus is on the waste generated from SUD hygiene products. That waste includes both the packaging in which the products come to the hospital, retailer, public or private facility, or person, and the healthcare or foodware item itself.

According to the World Health Organization (WHO) there are eight types of SUD healthcare wastes. They are general non-hazardous, infectious, pathological, sharps (syringes), chemical, pharmaceutical, cytotoxic, and radioactive waste (WHO, 2018). General non-hazardous waste comprises 85% of healthcare waste (DeVroom, 2019). The remaining 15% of healthcare waste – also known as regulated medical waste – is infectious or hazardous (WHO, 2018). Regulated medical waste is typically put in Hospital Medical Infectious Waste Incinerators or treated through thermal technologies, steam sterilization, electropyrolysis, or chemical mechanical systems to eliminate their infectious risk and then disposed of like non-hazardous waste in landfills or incinerators (U.S. EPA, n.d.). Non-infectious PPE is general non-hazardous waste, meaning it can be landfilled or incinerated, but does not require special waste treatment; it is treated like municipal solid waste (MSW). If PPE is considered infectious, then it is treated as regulated medical waste (CDC, 2022a).

Regarding SUD foodware items, these include but are not limited to plates, cups, lids, utensils, straws, napkins, clamshells, and bags. These are fossil fuel-based (e.g., plastic) or biobased (e.g., compostable). In the U.S., of SUD foodware, at most 52% are recyclable and at most 59% compostable (unlined paper/fiber items are both recyclable and compostable) (Moss & Grousset, 2020). However, those are only recycled or composted if local infrastructure and services foster such processes, if the waste stream is not contaminated, and if there is a market to purchase the recycled or composted material (Heiges et al., n.d.). Non-recyclable or compostable SUD foodware, or SUD foodware in jurisdictions without recycling and composting infrastructure and services, or if the waste streams are contaminated, are landfilled or incinerated (Moss & Grousset, 2020; U.S. EPA, 2020b).

Waste is a by-product of numerous factors, from design to production to use of products and packaging. Waste is therefore a problem not only because of the quantities generated along the lifecycle, but the hazards it (or its disposal) pose, the lack of disposal or recycling capacity, and the inequitable distribution of its impacts. We argue that the proliferation of hygiene waste during COVID-19 was due to 1) regulatory gaps in anti-SUD policies for healthcare and foodware items before COVID-19; and 2) the disregard for SUD waste by the three primary groups of waste-related decision-makers during COVID-19: governmental and agency, industry, and consumer actors. We therefore start with a review of the amounts and types of hygiene waste generated during COVID-19. From there, we discuss the anti-SUD healthcare and foodware policies enacted in the U.S. before COVID-19, then the U.S. actors and their decision-making drivers that resulted in hygiene waste. Then, we examine how the policy context coupled with the power and authority of the three actor groups during COVID-19 resulted in proliferated hygiene waste. We close with policy-based and actor-oriented recommendations to prevent hygiene waste in future disasters.

2. Hygiene Waste from the COVID-19 Pandemic

COVID-19 generated a massive quantity of hygiene waste. In the first few months of the pandemic in the U.S., the International Solid Waste Association (ISWA) estimated a 250-300% increase in SUD plastics waste, with the majority being healthcare and foodware waste (The Economist, 2020). One study estimated that across 193 countries, between March 2020 and August 2021, the pandemic resulted in the additional generation of 8.4 million tons of plastic waste (Peng et al., 2021). Another study corroborated that spike in plastic production, noting a 6.6 million ton increase between 2019 and 2021, due to the massive increase in demand for SUD plastics (Charles & Kimman, 2023). Between late 2019 and early 2021, general non-regulated healthcare waste (MSW) increased by 350%, 82%, and 62% in China, India, and Iran, respectively (Yousefi et al., 2021). Municipalities, waste service providers, and health care facilities were therefore ill prepared for the onslaught of new and overflowing waste; quite simply, waste treatment facilities became overwhelmed (Hantoko et al., 2021). Waste management

processes often rely on storage facilities as a component of their waste handling, but such facilities were not large enough for the sudden increases in hygiene waste (Cesaro & Pirozzi, 2020; Yu et al., 2020). Further, COVID-19-related waste was automatically categorized as hazardous, meaning it was redistributed through different processing channels, being incinerated or burned in unregulated manners and facilities and resulting in large waste dumps, thereby posing substantial health risks (Celis et al., 2021). There was neither the operational nor physical capacity to safely manage this growth in hygiene waste.

2.1. SUDs Healthcare Waste

Government and agency actors acted quickly to combat the spread of COVID-19 by promoting contagion prevention measures such as healthcare-based solutions. Their decisions resulted in the proliferation of three major SUD healthcare waste types: PPE, diagnostic tests, and vaccine waste.

For PPE, by January 2021, Hantoko et al. (2021) estimated 21,000 tons of mask waste were generated globally per day. Of that waste, it is estimated that in 2020, 1.56 billion masks entered marine environments globally (OceansAsia, 2020), and since the start of COVID-19, over 28,500 tons of plastic PPE entered ocean environments globally (Peng et al., 2021). PPE waste rates varied based on jurisdictional mandates. For instance, there was less per capita SUD mask waste in England compared to Italy, likely due to the English government's promotion of reusable masks (Johansson, 2021). The rise in PPE influenced a rise in litter and a change in its composition, which became known as 'Coronalitter' and 'Coronawaste' (Garnett et al., 2022). However, litter did decrease in some areas due to pandemic-related curfews (Johansson, 2021). Masks have now firmly situated themselves as part of contemporary waste (Schofield et al., 2021).

There are two types of diagnostic testing waste: healthcare administered diagnostic tests and home diagnostic tests. Early in the pandemic, healthcare administered diagnostic tests – real-time polymerase chain reaction (RT-PCR) tests – were widely used to confirm if a patient had COVID-19. All RT-PCR tests are SUD and according to Celis et al. (2021), the average RT-PCR test uses 37.27 grams of plastic, from sampling (e.g., swab, tube) to processing (e.g., tubes, tips, caps). Therefore, by August 2020 (roughly 4.5 months), over 15,400 tons of plastic waste were generated globally as a part of case confirmation.

For home diagnostic tests, all waste material generated is general, non-hazardous (MSW), with only the cardboard packaging and paper instructions being recyclable (Tsagkaris et al., 2022). As individuals sought to travel, return to work in-person, attend events, and otherwise engage outside of their homes, home diagnostic tests use and, thus, waste rose (Yousefi et al., 2021; Zand & Heir, 2020). One researcher examined the environmental impact from plastics in the home diagnostic tests, noting that the typical test consists of 10 grams of non-recyclable plastic and its production generates roughly 22.5 grams of carbon dioxide equivalent emissions (Loumakis, 2021).

Vaccine waste occurs throughout the vaccine lifecycle, from the vaccine development phases (e.g., research and development, manufacturing, and clinical trials) to the use phase when administering a vaccine. The waste during the development phase can be exorbitant because of all of the testing required. For instance, up to 85% of clinical trials are unsuccessful in yielding an effective, safe vaccine (Glasziou et al., 2020). These are necessary steps to find the right candidate, however, they also result in waste. Administering vaccines leads to sizable waste as well: an estimated 13 billion vaccines were given between December 2020 and December 2022, with the cleaning paraphernalia, syringes, and containers all classified as regulated medical waste (hazardous) (Our World in Data, 2023). In addition, a significant fraction of vaccines is unused and eventually expires. The CDC estimated that between December 2020

and mid-May 2021, 82 million COVID-19 vaccines – or 11% of the doses distributed by the U.S. federal government – were wasted (Eaton, 2022). Further, to inoculate 60% of the world’s population – the proposed threshold for herd immunity – between 800 billion and 1,000 billion syringes would be needed (Mittal et al., 2022).

2.2. SUDs Foodware Waste

Like SUD healthcare waste, no new types of SUD foodware waste were introduced during COVID-19, just far more of the preexisting SUD foodware waste types. Hantoko et al. (2021) estimated a 45% increase in plastic packaging waste due to food delivery and online grocery delivery. Takeout and delivery became so popular during the pandemic, that some food businesses launched virtual-only ‘restaurants’ with no dine-in capability, thus becoming exclusively dependent on SUD foodware (Breheny, 2022). Premade and ready-to-eat meals with plastic trays, cling wrap, and cardboard packaging, while not new because of COVID-19, were more commonly used because of COVID-19 as they were provided for those in quarantine or lockdown (Yousefi et al., 2021), given as aid to those displaced (World Food Program USA, 2022), and enjoyed by many consumers for their convenience and decreased virus exposure (Feber et al., 2020). This waste was likely landfilled, incinerated, or exported and dumped. During COVID-19, the U.S. plastics recycling rate dropped from 9% to 4-5% (Greenpeace, 2022).

The provision of SUD foodware accessories (e.g., utensils, napkins, plates) by food businesses became so commonplace that the nonprofit Upstream began a #SkipTheStuff campaign, which advocated for consumers to actively decline accessories when ordering, and for food delivery apps to have a feature in the checkout process for customers to choose if they wanted accessories with their order (Upstream, 2022a). Governments were urged to pass legislation to ban food businesses from automatically providing accessories.

Overall, COVID-19’s hygiene waste was costly for municipalities and waste service providers to collect and manage (Sinha et al., 2020). It required last-minute and thus haphazard processes and operations due to the different technologies needed to handle the material, the rise in waste materials that could be dangerous for a worker (e.g., syringes puncturing a garbage bag), and the altered routes because of the shift from mostly commercial to mostly residential waste (Valizadeh et al., 2021). It was oftentimes exceedingly unsafe for workers due to delayed training or undertraining in the new processes and operations and heightened exposure to the virus (Behera, 2021; Rosengren et al., 2021). Further, all of these changes resulted in the immediate need for new and more labor (Rosengren et al., 2021), and strained existing waste management infrastructure (WHO, 2022a).

3. Anti-SUDs Policies Before COVID-19

Before COVID-19, the healthcare and foodware sectors were characterized by very different policy regimes and pressures regarding reducing the use of SUDs. The anti-SUD foodware policy transition began in the 2000s, with its main focus on specific foodware items (e.g., plastic bags and plastic straws) (Clapp & Swanston, 2009; Mosquera, 2019). This transition (also known as the anti-SUD foodware norm emergence), has catalyzed policy to both support reusable foodware alternatives and weaken SUD foodware incumbents (Heiges, n.d.). It contains activist organizations from the local to global level, resulting in action at all jurisdictional levels.

Conversely, the pre-pandemic anti-SUD healthcare policy transition was nascent. There were only two prominent organizations focused on such efforts, Practice Greenhealth and Healthcare Plastics Recycling Council, both of which have industry members. This minimal activism, confined to specific

healthcare actors, could be linked with the lack of anti-SUD healthcare policies at any jurisdictional level.

3.1. Anti-SUD Foodware Waste Policies Before COVID-19

Prior to COVID-19, the anti-SUD policy transition for foodware in the U.S. had reached a period of heightened progress and stability. That progress was evident through a more robust policy mix, which is the adoption of ‘creative’ and ‘destructive’ policies that both fostered innovations and eroded market strongholds (Kivimaa & Kern, 2016). For anti-SUD foodware, across jurisdictional levels in the U.S., there were policies in five of the seven creative policy categories and three of the four destructive policy categories, as shown in Table 5.1.

Policy Mix	Examples of Anti-SUD Foodware Policies in the U.S.
Creative	
Knowledge creation, development and diffusion	Chapter 4.107 - Regulating the Use of Disposable Food Service Ware (San Mateo County, California); Colorado House Bill 22-1355 (Colorado)
Establishing market niches/market formation	Maine Legislative Document 1541 (House Paper 1146) (Maine); NO. 180519 - Single-use Food Ware Plastics, Toxics, and Litter Reduction Ordinance (San Francisco, California); SB 343 - Accurate Recycling Labels (California)
Entrepreneurial experimentation	SB 54 - Solid waste: reporting, packaging, and plastic food service ware (California)
Support from powerful groups/legitimation	Maine Legislative Document 1541 (House Paper 1146) (Maine); NO. 180519 - Single-use Food Ware Plastics, Toxics, and Litter Reduction Ordinance (San Francisco, California); Oregon State Senate Bill 582 (Oregon)
Influence on the direction of search	Colorado House Bill 22-1355 (Colorado); Maine Legislative Document 1541 (House Paper 1146) (Maine); Oregon State Senate Bill 582 (Oregon)
Destructive	
Control policies	Bill 22596 - Single-Use Plastics Ordinance (Bellingham, Washington); Colorado House Bill 22-1355 (Colorado); Section 4-8-065: Single-use Foodware (Chicago, Illinois); Single Use Foodware and Litter Reduction Ordinance (Berkeley, California)
Significant changes in regime rules	Ordinance 2045 - Reusable Food Service Ware and Plastic Waste Reduction (Palm Springs, California); SB 54 - Solid waste: reporting, packaging, and plastic food service ware (California)
Changes in social networks, replacement of key actors	AB 1583 - The California Recycling Market Development Act (California)

Table 5.1: The policy mix of anti-SUD foodware pre-COVID-19 in the U.S. This chart is a breakout of the policy mechanisms before COVID-19 at various jurisdictional levels in the U.S. as part of the anti-SUD foodware transition. At the time, there were policy mechanisms in five of the seven creative policy categories and three of the four destructive policy categories.

Prior to COVID-19, anti-SUD foodware policies had a low level of ‘intensity’ (Schmidt & Sewerin, 2019). This meant that implemented policies were not fully integrated (many were new and had a phased-in approach so they were not fully adopted at the time of the pandemic); they had limited or no

budget; their implementation pathway was ill-defined or crossed numerous governmental departments and non-governmental stakeholders; and they had limited or no monitoring mechanisms (Heiges, n.d.; Upstream, 2022). In other words, most actors did not see anti-SUD foodware policy as a fundamental or entrenched part of the policy, industry, practice, and institutional landscape. There were, of course, exceptions to these trends in that there were a few extended producer responsibility (EPR) policies (Heiges & O'Neill, 2021) and material bans that had strong integration, budget, implementation, and monitoring (Wagner, 2017; Wagner et al., 2013). However, those policies were the exception, not the norm.

Additionally, prior to COVID-19, anti-SUD foodware policies primarily relied on only two alternative innovations, which is a risky approach in sustainability transitions because there is no single innovation that can “address all of the identified failures, bottlenecks, or risks” that necessitated a transition (Schmidt & Sewerin, 2019, p.2). So, a balanced and comprehensive mix of alternative innovations is needed (Kivimaa & Kern, 2016; Schmidt & Sewerin, 2019). Those innovations were the requirement that customers bring their own reusable item (e.g., bag or cup) and that food businesses (e.g., restaurants, cafes) provide all items consumed on-site in reusable foodware. These innovations were swiftly abandoned in COVID-19 (Restaurant Business Staff, 2020; Rosengren & Rachal, 2021).

3.2. Anti-SUD Healthcare Waste Policies Before COVID-19

Before COVID-19, in the U.S., there were no policies specifically focused on reducing the amount and type of SUD healthcare waste. The only policies in the SUD healthcare sphere are those that determine how such waste is managed (e.g., parameters that categorize the material as hazardous, how the material can be handled and treated), not mechanisms to disincentivize the generation and use of SUD healthcare items (Levchenko & Schweikart, 2022). The only moderately related anti-SUD healthcare policy is at the state level, colloquially known by its education and awareness campaign name, “no drugs down the drain”. These policies, like Senate Bill 966 in California (Wiener, 2018), promote resources and programs, like a take-back system, for the safe collection and disposal of pharmaceuticals. While pharmaceuticals are one of the eight healthcare wastes, they are not SUD, nor a product or package aimed at preventing contagion. This waste differs from vaccine waste, for instance, because vaccine waste comes from a SUD syringe to promote disease resistance and resilience. Furthermore, the canister that holds the pharmaceuticals is not part of the take-back program. We therefore do not consider Senate Bill 966 or related laws in other states as an anti-SUD healthcare policy.

In the absence of policies, the two aforementioned organizations in anti-SUD healthcare focused on catalyzing infrastructural and procedural changes to reduce SUD healthcare waste. The most extensive anti-SUDs practice is pharmaceutical companies providing patients with mail-back or container collection programs to safely return their sharps (e.g., needle, syringe). Additional programs aimed to reduce waste are reusable disposal fluid suction canisters for operating rooms or waste stream separation for less material contamination and thus higher recycling rates. However, those limited procedural and infrastructural approaches were the extent of the anti-SUD healthcare transition, policy or otherwise, in place before COVID-19 (Levchenko & Schweikart, 2022).

Pre-pandemic, the anti-SUD foodware policy space was far more advanced than the anti-SUD healthcare waste policy space, however it was still decentralized and fragmented, focused on disparate approaches, with different amounts of support and integration into food systems. Furthermore, while the anti-SUD foodware policies were growing, they were still emerging, making them vulnerable to outside threats, like a disaster (Heiges, n.d.; Heiges & O'Neill, 2021). Since there were no anti-SUD healthcare waste policies, there was no legislative structure in place to weather any sort of health-related disruption. So, pre-pandemic, while the anti-SUD foodware transition was occasionally slowed

by disjointed policy action, the anti-SUD healthcare transition was slowed by policy inaction. We posit that the lack of maturity of anti-SUD policies in place pre-pandemic influenced the amount of related waste generated during the pandemic.

4. Drivers of Hygiene Waste during the COVID-19 Pandemic

Decisions and authority related to hygiene waste during COVID-19, like the anti-SUD foodware policies, were decentralized and fragmented, sparked from different actors and driving forces. Below we describe the three main actors (government and agency, industry, and consumer) at various levels and authoritative power in the U.S., their decision-making drivers, and their respective decisions. These are positioned around how they resulted in hygiene waste, undermining existing anti-SUD policies and the anti-SUD norms, and changing distribution of hygiene waste (household waste and litter), with little improvement of MSW facilities.

Frameworks that can influence actors' decisions during a disaster are disaster mitigation frameworks (Brown et al., 2021), and were therefore a starting point for our analysis. We analyzed the six leading disaster mitigation frameworks based on scholarly publications to assess their fields, tools, and objectives as they relate to disaster waste prevention and mitigation. Only one of the six frameworks includes disaster waste planning (Disaster Response Planning), insinuating that decisions from actors during the COVID-19 disaster were largely made without considering hygiene waste or how those decisions would impact anti-SUDs transitions.

4.1. Governmental and Agency Actors

On January 30th, 2020, the World Health Organization (WHO) declared COVID-19 to be a public health emergency of international concern (Kupferschmidt, 2020; PAHO, 2020). That was only the sixth declaration of this type by the WHO since the agency first introduced it 15 years prior. On March 11th, the WHO categorized COVID-19 as a pandemic (WHO, 2022b). On March 13th, the U.S. federal government declared a national emergency concerning COVID-19 (Federal Register, 2020) and thereafter all 50 state governments declared their equivalents of a state of emergency (NASHP, 2022). The WHO, a United Nations agency charged "to promote health, keep the world safe and serve the vulnerable" (WHO Team, 2019), had the power and authority to catalyze immediate governmental action.

The declaration of emergency for COVID-19 put the protection of public health at the top of the federal government's priorities (Garnett et al., 2022). However, the federal government faced substantial uncertainty as to what actions might work to control the disease's spread because of the virus' novel nature and the government's lack of preparation for such a wide-spread and immediate disaster (Greer et al., 2020). What mattered to the federal government were immediate decisions and actions to try to forestall a worsening disaster, and potential long-term harms from decisions (Garnett et al., 2022), like proliferating hygiene waste, were neglected and de-emphasized. This is also a function of the lack of federal legislation and control of waste and recycling in the US (Heiges and O'Neill 2022)

Governments around the world almost immediately implemented numerous non-pharmaceutical interventions (NPIs) to mitigate the spread of COVID-19. In a study conducted across 79 territories worldwide, at the start of the pandemic there was no uniformity on governmental actions and all jurisdictions took numerous actions (Haug et al., 2020). Due to the imminent danger of the virus and the fact that healthcare systems were increasingly overwhelmed in a short time, the U.S. federal government acted, in part, for the sake of acting (Galaitis et al., 2021); to appear in control and mitigate fear, to appear to be alleviating threats and harm, and to appear to be supporting public health.

State governments were positioned between the federal government and agencies – needing to abide by their mandates (though occasionally disregarding them) – and local governments which implemented quick, community-centric support (Dzigbede et al., 2020). State governments therefore did not have much power. Some state governments feared the risk of litigation from the changes of power and priorities. Not only was this concern for litigation against themselves, but also litigation against some of the entities that they had newfound authority over due to the national emergency, including companies and healthcare workers. In late 2020 and early 2021, 30 U.S. states implemented liability protections to safeguard companies and reduce legal liability against potential lawsuits from workers, clients, or vendors for harms caused by their actions or products in responding to COVID-19 (Povich, 2021). For healthcare workers, the Medical Defense Union (MDU) demanded doctors receive immunity from civil liability and malpractice claims (Peabody & Brinkman, 2020).

Furthermore, as a component of the shifting powers and authorities under an emergency, various state governments declared healthcare workers, food business employees, and waste service providers to be “essential workers”. The designation of being an essential worker meant participation in activities of heightened exposure to COVID-19. It also meant that such workers should receive PPE and hazard pay, but both were not always realized (Klemes et al., 2020; OSHA, 2021a; Rosengren & Crunden, 2020). The lack of wages, benefits, and rights coupled with heightened exposure and disease incidence resulted in a labor shortage across industries (Stiles, 2021).

Throughout this all, local governments were looked to for guidance and relief, but also undermined in credibility and authority (McDonald et al., 2020). Local governments led the initial COVID-19 response by introducing mass lockdowns (which states then the Centers for Disease Control and Prevention followed and codified). Further, these disparate entities, in an uncoordinated manner, changed the roles and responsibilities of their employees to triage COVID-19 response and recovery, thus intentionally or unintentionally pausing any anti-SUD foodware policies, which were at the local level for the majority of such policies (Karasik et al., 2020; Upstream, 2022). During COVID-19, local governments and providers had to react to the federal government decision – which was similarly made in many other countries – that all healthcare waste should be treated as regulated medical waste, thus hazardous (Yousefi et al., 2021), which meant it needed to be combusted instead of landfilled. It is also unclear if most local governments had a disaster mitigation framework in place before COVID-19. Even if a local government had such a framework, the likelihood of that framework including disaster waste mitigation was small (Dzigbede et al., 2020; WHO, 2021).

In the U.S., the Centers for Disease Control and Prevention (CDC) is a national agency, under the Department of Health and Human Services, that promotes public health by making decisions on practices to adopt, designing and releasing information, and overseeing testing and vaccinations. In the early days of the pandemic, there was, understandably, limited, disparate, uncoordinated, obfuscated, and lagging information on the novel virus’ properties (Galaiti et al., 2021). The virus spread faster than research findings could inform decisions, which meant the precautionary principle was applied; sometimes decisions were made before there were data, with ignorance of data, or despite the available data (Galaiti et al., 2021). This meant that early on there was tremendous and pervasive uncertainty, spurred by assumptions, such as the virus’ transmission properties. The CDC tried to maintain authority, but that was eroded through conflicting data and levels of jurisdictional governance (LaFraniere & Weiland, 2022). The CDC’s decisions thereby influenced other actors’ decisions, either because of their authority or because of the erosion of their authority.

Healthcare facilities (e.g., hospitals, public health systems, medical clinics) wanted to combat the terrifyingly quick spread and harmful impact of the virus in a fairly short time, and therefore took

any actions available to curb transmission (Garnett et al., 2022), regardless of whether those actions were scientifically sound (Klemes et al., 2020). Medical health professionals were the ones administering the care, meaning they played a particularly important role in generating hygiene waste, but they did not necessarily have the power and authority to decide if such waste-generating practices should happen; they had to do them due to directives from the WHO, the CDC, and the U.S.'s Occupational Safety and Health Administration (OSHA) (CDC, 2021a; OSHA, 2021b; WHO, 2020). This was especially true after the first few months of the pandemic, once federal intervention began (Dzigbede et al., 2020).

Waste service providers faced a situation of having to manage the waste generated, but had almost no power and authority over what type of waste was generated, or how much. They, however, played a crucial part in helping 1) single out hygiene waste for special treatment; and 2) determine whether hygiene waste could be managed efficiently, with fewer impacts on ecosystems and marginalized communities, through developing new disposal practices. Disposal techniques varied by jurisdiction, region, and available technology and labor. This was prominent in the U.S. (Rosengren & Rachal, 2021) and exemplified in research studies conducted internationally. For instance, municipalities in China implemented three moveable disposal technologies (Zhao et al., 2021). Romania required all quarantined persons to dispose of their waste in different bags that were then collected by special waste service personnel in defined vehicles and full PPE (Mihai, 2020). Mihai (2020) also discussed how waste service providers optimized routes to decrease exposure, conducted additional audits on hazardous waste processing facilities to ensure containment, and directed transport of medical waste to incinerators. Further, since there were fears of transmission and contamination through conventional equipment, specialized equipment was used to handle COVID-19 hygiene waste (Yousefi et al., 2021). Finally, there was a conflicting split of strategies in some regions to either increase waste storage time – ‘resting time’ – before disposal (Tripathi et al., 2020) or to reduce waste storage time (Yousefi et al., 2021), both with the intention to reduce transmission. Ultimately, waste service providers had to be flexible and adapt at great lengths (Mahyari et al., 2022).

Governmental and agency actors, like the CDC, healthcare facilities, and waste service providers, therefore played a role in developing pandemic-related technologies and helped inform policy changes which governmental actors enacted, but they were also impacted by policy changes. For instance, based on the CDC's recommendations – and adopted by the federal government – some jobs required the use of PPE, vaccinations, and employees to test if they had the virus before working (OSHA, 2021b), all of which generated hygiene waste. Within healthcare facilities, additional cleaning protocols were added, prescription medication take-back programs were paused, sharps take-back programs were paused, reusable medical items were reduced or prohibited, and cafes at healthcare facilities closed. Food businesses were no longer allowed to have on-site diners (OSHA, 2021a) and could only supply take-out food, meaning hygiene waste was generated with each order.

The heightened demand for SUD healthcare and foodware items based on policy changes was problematic because many healthcare systems and food businesses had become reliant on ‘just-in-time’ ordering to reduce storage capacity needs and expired materials, which made them “vulnerable to disruptions from manufacturing shortages, interrupted transportation systems, international trade dynamics, and price shocks” caused by COVID-19 (MacNeill et al., 2020, p.2089).

4.2. Industry Actors: The Plastics Industry, and Food Businesses

The federal government's preexisting relations with industry actors were disrupted during COVID-19; power dynamics, interests, and allegiances changed (Benton, 2020; Xu & Basu, 2020). Its fear and uncertainty created an opportunity window for those with vested interests to lobby for their

interests and thus take advantage of the state of emergency. Naomi Klein (2007) described this practice of businesses taking advantage of this heightened state of vulnerability to urge significant policy changes that end up benefiting them as “disaster capitalism”. Industry actors exploited the fear and uncertainty of the pandemic to press for anti-SUD transitions to be paused or abandoned.

Industries with vested interests are characterized by their ability to mobilize quickly and at scale, their position to gain substantially from public sector decisions, and their ability to enact powerful means of persuasion. The plastics industry had a deep vested interest in re-expanding the use of SUD healthcare and foodware items because plastic is the main material type for those SUD items, and the industry had been losing market share in that sector. This pre-pandemic plastics industry downturn was due to the anti-SUDs policy transition (Heiges, n.d.), the severe impact that Operation National Sword (China’s plastics scrap import policy) had on the plastics market and recycling (Heiges & O’Neill, 2022), and the initial and sizeable drop in market value that plastics experienced at the start of the pandemic (FRED Economic Data, 2022).

To make the case for greater SUD use, the plastics industry argued SUDs provided a seemingly cost-effective, immediate, and guaranteed solution for preventing the spread of the virus, which was what governments urgently wanted at the time. Those attributes were part of a discourse the plastics industry has been perpetuating for decades (Markowitz & Rosner, 2013; Risch, 2009; Vogel, 2009). The Plastics Industry Association (PIA) – the lobbying body that represents chemical companies manufacturing plastics – released an open letter to the U.S. Department of Health and Human Services on March 18th, 2020, a week after the WHO declared COVID-19 a pandemic (Heiges & O’Neill, 2020; Radoszewski, 2020). This letter lambasted all reusable items (e.g., beverage cups and shopping bags) as posing virus transmission risks and advocated for a complete ban on reusable items. The argument depended on a then-prevailing assumption that the virus spread on surfaces, among other pathways, and took advantage of the significant uncertainties around transmission to further industry interests and intervene in the national dialogue on how to slow the spread of COVID-19 (Johansson, 2021).

It is therefore plausible that the actions PIA took were acts of disaster capitalism, meaning PIA had much to gain from governments pausing, delaying, or rolling back anti-SUDs policy. Greenpeace later contended that PIA’s claims were not scientifically sound in that they were based on extrapolations from research on bacteria versus the COVID-19 virus, which hold vastly different transmission and infection properties (Schlegel & Gibson, n.d.).

PIA’s ability to shape the national dialogue was boosted by a common, preexisting misconception that SUDs are highly sanitary and potentially more sanitary than their reusable counterpart (Thompson, 2020). Recent scientific studies suggest that instead of SUDs or reusable items being uniformly more sanitary than the other, the production, storage, and cleaning procedures of such items dictates cleanliness (Tan et al., 2021; Tan et al., 2022). PIA, however, successfully influenced the national (and international) dialogue during COVID-19 (ClimateTracker.org & #BreakFreeFromPlastic, 2021) encouraging governments and agencies, food businesses, and consumers to believe in the power of SUD items to protect themselves (Prata et al., 2020). That influence was palpable in two notable ways. First, the U.S. and U.K. government declared plastics manufacturing to be an essential industry during COVID-19 to support relief efforts (Johansson, 2021), thereby giving preferential legislative treatment and financial assistance to such companies. Second, individuals engaged in a phenomenon of SUDs-based “hygiene theater” to convey their actions towards protection (Thompson, 2020), even after it became clear that the virus spread through the air, not via surfaces (Hale & Song, 2020).

The other main industry actor that influenced hygiene waste generation during the COVID-19 disaster were food businesses (e.g., restaurants, cafes, grocery stores). Unlike the plastics industry, food businesses did not mobilize as quickly, as extensively, or as publicly. Pre-pandemic, food businesses were already vulnerable, with low margins, high liability, and unpredictable labor and supplies (Enz, 2004; Glanz et al., 2007). At the beginning of the pandemic, food businesses suffered substantial losses of markets and sales during lockdowns and then periods of restricted dining. For example, Darden Restaurants Inc., the largest full-service dining restaurant in the U.S., permanently or temporarily closed all 1,800 locations at one point (Yost et al., 2021). Furthermore, food business employees and delivery workers faced higher exposure to contagion and frequently fell ill (Bhuiyan, 2020), creating labor shortages, depending on where a food business was placed in the larger supply chain (Karniouchina et al., 2022). With restricted dining came a reduction in labor needs. As a result, many food businesses experienced even lower margins than before the pandemic (Yost et al., 2021). However, for those who were ready and able to engage in a few operational innovations, maintenance or even growth was possible. The two operational innovations that outpaced their pre-COVID-19 growth trajectory were takeout and delivery for food and groceries.

In the U.S., the delivery of takeout food grew between four and seven times from 2018 to 2021 (Edison Trends, 2021). This was after the initial food business setback where restaurants, cafes/bakeries, and fast food establishments were forcibly closed for 3-4 weeks when the outbreak began (Restaurant Business Staff, 2020). Decisions for the closures were on the state and local level as the virus spread and harm was rapidly emerging but before there was clear guidance from the federal government or agencies (Restaurant Business Staff, 2020). Once businesses that were forcibly closed were able to reopen due to the easing of state and local mandates, they focused on outdoor dining (because indoor dining was still restricted by the CDC) and takeout and delivery. Also in the U.S., grocery delivery grew from \$1.2 billion in sales in August 2019 to \$7.2 billion in sales in June 2020 (Ozbun, 2022). Takeout and delivery for food and groceries require SUD foodware, especially because a consumer's personal mug or bag cannot be used, plus items like SUD utensils and napkins were often provided automatically. Therefore, those operational innovations, while supporting the financial viability of the food business and providing needed and/or desired food to consumers, resulted in hygiene waste.

There were no material innovations in foodware technology during this time. Instead, food businesses reverted to incumbent materials, such as fossil fuel-based rather than biobased SUD items. This was due, in part, to supply chain accessibility. There is a larger, more stable supply of fossil fuel-based SUD items, especially compared to the emerging and thus relatively limited supply of biobased SUD items (Feber et al., 2020). Further, biobased SUD items are more expensive than fossil fuel-based equivalents, so as food businesses were scrambling to adjust to new mandates and thus operations, they reverted to lower-cost, available, and familiar supplies (Feber et al., 2020). Additionally, food businesses wanted to appear hygienic. This was especially true because of the prevailing initial and now debunked assumption that the virus transmitted via surfaces, so food businesses opted for SUD items (Dey & Michael, 2020; Klick & Wright, 2013). The costs, convenience, and hygienic image of SUD items, coupled with the ban on reusable foodware, meant there was no demand for material innovation in foodware technology. The combination of incumbent SUD materials with heightened food and grocery delivery rates led to a resurgence of SUD waste that the anti-SUD foodware policy transition had aimed to curb, as government actors decided to pause such policies during COVID-19.

4.3. Consumer Actors

The third group of actors that influenced the amount and type of hygiene waste generated during the COVID-19 pandemic was consumers. The early fear and uncertainty experienced in

governmental and agency actors, and some industry actors, were felt by consumers as well. That fear and uncertainty manifested in unpredictable decisions and actions. For instance, there was an immediate rise in consumer desire to protect their health and assure their access to necessities, seen in the panic purchasing of foodstuffs and toilet paper (Broadman, 2020). Consumers were desperate to quarantine themselves and their families from the health risks of COVID-19 so they also bought products perceived to reduce these risks (Szasz, 2007) and heeded the warnings of businesses and governments about reusable items. Further, consumers moved out of cities for more space, protection from contagion, and/or to quarantine (Frost, 2021). However, there was also skepticism among some consumers about healthcare approaches plus ardent belief in non-medical solutions, which spurred conspiracy theories, direct disregard of mandates, and talisman or other superstition-based activities, all of which either rejected learned properties of the virus or aimed to enact non-governmental or non-scientific forms of curbing its spread (Imhoff & Lamberty, 2020; Kotta et al., 2021; Rothmund et al., 2022). Consumer action was therefore unpredictable and hard to control.

These varying decisions and actions meant that there were different types and higher quantities of residential wastes generated than usual, which disrupted and, in some cases, strained waste service operations (Hantoko et al., 2021). There was more SUD foodware waste, healthcare waste, and delivery-related packaging waste (Hantoko et al., 2021). While it is possible that there was more consumer awareness of hygiene waste compared to before the pandemic because such waste was disposed of in consumers' residences versus public areas or commercial facilities (Hester, 2021), consumers could not readily engage with anti-SUD systems (e.g., reusable foodware or healthcare items) because of restrictions and mandates imposed by government and agency actors (CDC, 2021a; OSHA, 2021b; WHO, 2020).

5. Preventing Hygiene Waste in Future Disasters

In summary, the anti-SUD healthcare and foodware transitions were not mature and societally embedded enough to withstand the sudden and massive disruption that responses to COVID-19 created. Below are actor and policy recommendations to strengthen the respective transitions, and thus prevent harmful and uncontrollable amounts of hygiene waste in future disasters. This is a unique examination of a particular waste stream within disaster waste, thereby informing nuanced theory within disaster waste literature.

5.1. Actor-Oriented Recommendations

Government and agency actors need to adopt and/or incorporate the issue of hygiene waste into their disaster mitigation frameworks. In some cases, agency actors that created or were impacted by hygiene waste during COVID-19 are not designed to provide disaster support. In those cases, instead of adopting a disaster mitigation framework, they need to think more about disaster contingency plans, such as pandemics, and must include attention to hygiene waste. For those expected to provide disaster support, hygiene waste – or even the larger umbrella of disaster waste – is only acknowledged in one of the six leading disaster mitigation frameworks. That means that actors, whether local or international, were not equipped for the extreme resource demand, supply chain strain, and disposal needs of a disaster that called for hygiene-promoting actions and resulting hygiene waste. That meant that fostering anti-SUDs practices during COVID-19 was not integrated into decision-making and actions. The frameworks must be updated to integrate hygiene waste considerations and the actors using such frameworks must adhere to those updates.

Some hygiene waste will still be needed in a disaster (e.g., PPE and tests), so we need to design hygiene products (e.g., foodware and healthcare items) to be as reusable and recyclable as possible, to

have as few toxic and unsustainable constituents as possible, to be managed by preexisting waste operations as much as possible, and to be as easily and conveniently deployed as possible. We need government and agency actors to support the growth and adoption of these systems – especially reuse and recycling infrastructure – in non-disaster times so they are integrated into the system when a disaster hits. This aim for SUD item elimination in non-disaster times will support the reduction and prevention of SUDs, especially hygiene-related SUDs, during a disaster.

While there were other stakeholders involved in galvanizing anti-SUD transitions, the anti-SUD foodware transition in particular was grounded in policy and predominantly facilitated by different levels of government. Governments often play crucial, unique roles in transitions, such as fostering policy-based sustainability innovation (Nill & Kemp, 2009). However, because the anti-SUD foodware transition was grounded in policy that could readily be suspended or reversed, and both the anti-SUD foodware and healthcare waste transitions were largely reliant on influencing the informal practices of consumers, that left the transitions more vulnerable to large, outside threats. As we explain below, governments can make anti-SUD transitions more robust by strengthening their policies, and can better address hygiene waste by requiring recycling and reuse infrastructures to be expanded, alongside designing products for these.

The anti-SUD transition vulnerability was exacerbated by governmental actors shifting their roles as they triaged around the novel virus and created a window of opportunity for the plastics industry to capitalize on its preexisting governmental relations and take advantage of governments' and businesses' fear and uncertainty due to the virus. We recommend stronger safeguards to not allow vested interests to have unfair access and control during crises, such as critically evaluating claims by industry actors, limiting unequal lobbying and influence by industry actors ahead of civil society and public health actors in general, and limiting participation of industry actors on advisory panels.

Regarding consumers, we need measures in place to not rely on their action as the sole steward of sustainability, but instead provide upstream anti-SUD support. Rather than simply nudging or forcing consumers to participate in less wasteful practices, governments and institutions could make such practices inaccessible, inconvenient, or deprioritized to begin with. Further, a consumer can only be as sustainable as the culture and consumption system in which they live. Part of the demise of the anti-SUD transitions during COVID-19 was because they were so reliant on consumer action, like bringing one's own reusable cup or sending back their used sharps. More upstream systems, like transferring waste disposal responsibility to producers from waste service providers, eliminating toxic and unsustainable constituents, requiring minimum recycled content in products to decrease the amount of new feedstock needed, and reducing barriers for reusable systems, aim to adjust the system outside of the consumer, thereby encourage more collaboration and system embeddedness, potentially resulting in a more resilient sustainability transition (Heiges, n.d.; Heiges et al., n.d.).

5.2. Policy Recommendations

We suggest key policy recommendations to support the anti-SUD healthcare and foodware transitions and thereby increase the likelihood of less hygiene waste production in future disasters. The recommendations apply to both anti-SUD healthcare and foodware. However, since no anti-SUD healthcare waste policies currently exist in the U.S., the main recommendation here is to begin implementing such policies, and the specific recommendations pertain to the anti-SUD foodware transition.

First, we recommend a more robust anti-SUD policy mix by increasing the intensity and technology-specificity of such policies. This intensity includes measures to support anti-SUD

mechanisms, such as more budget for their implementation, more oversight to ensure implementation, and greater enforcement to drive urgency and compliance. These measures, especially adopted in non-disaster conditions, could create greater societal embeddedness and therefore greater resiliency when tested by outside threats, such as disasters. Further, if they become embedded, like the styrofoam ban in the Bay Area, there will not be a resurgence – or the resurgence will be stunted – during a disaster. For technology-specificity, this includes more alternative technologies, such as reusables or take-back systems. This is key because there were few and only nascent anti-SUD technologies in place before COVID-19, which contributed to the proliferation of SUD items during the pandemic. If policy fosters the development – and thus societal embeddedness – of alternative technologies, then if one technology is deemed inaccessible, too expensive, or prohibited by mandates, other technologies can still persist. For instance, if bulk bins at a grocery store were more commonplace pre-pandemic, it is possible that such an anti-SUD foodware technology would have been reinstated quicker once it was confirmed that COVID-19 was not transmitted via surfaces. To create a more balanced, and thus more robust policy mix, it is important to have both creative and destructive policies (as shown in Table 5.1), which foster alternative systems and erode incumbents. Developments in policy intensity and technology-specific could support a more resilient sustainability transition and thus less hygiene waste in a future disaster.

To fulfill the needed policy intensity and technology-specificity policies to harden the anti-SUDs transition, we recommend including anti-SUDs as a component of the Health in All Policies (HiAP) initiative. HiAP recognizes that health is directly or indirectly influenced by all policies, thus should not only be a consideration but included in all policies (Rudolph et al., 2013). The anti-SUD components that could be included in HiAP are the prioritization of reuse and the elimination of toxic substances. A related policy approach is ‘bandwagoning,’ where actors include anti-SUD components in otherwise tangential initiatives to further their own agenda (O’Neill, 2018). This tactic might be feasible for anti-incineration efforts or the development of biobased SUD materials. A recent example of this HiAP and bandwagoning approach for anti-SUDs was with the U.S.’s Infrastructure Investment and Jobs Act of 2021 and the Inflation Reduction Act of 2022 where anti-SUD policy was included in legislation that otherwise did not focus on anti-SUDs.

These recommendations are coalesced around the terrifyingly quick and expansive uptick of SUD healthcare and foodware waste during the COVID-19 disaster, which was so expansive, it warranted a term to categorize the waste stream, hygiene waste. Besides providing a categorization for this novel disaster-related waste stream, which aims to spur research and action to better understand its harms and solutions, we sought to elucidate the impact three actor groups had on the anti-SUDs transition and provide recommendations to preempt exorbitant waste generation in the next disaster. This is an emerging approach for both sustainability transitions and waste studies; one that uses a disaster to examine the structural integrity of a transition and opportunities to bolster its resilience. Further, it underscores the importance of creating a coordinated and balanced policy approach for anti-SUD healthcare waste, an under-discussed omission in the larger anti-SUDs sustainability transition.

6. Conclusion

COVID-19 was a disaster that resulted in unprecedented rates of waste from products and procedures aimed to promote cleanliness and halt contagion. We term this waste stream hygiene waste, which includes SUD foodware and healthcare items. Like COVID-19, the related hygiene waste had a rapid emergence and was problematic on a large scale. We attribute the resulting problems and scale of hygiene waste to decisions made by three groups of actors: governments and agencies, industries, and consumers.

Prior to COVID-19, the anti-SUDs transition was gaining policy momentum for anti-SUD foodware waste, and procedural momentum for all hygiene waste types. The policy and procedural momentums, however, were uncoordinated and disparate, both within foodware and healthcare, and between the two. Furthermore, neither the transitions nor societies were prepared to manage disaster-related hygiene waste because disaster waste was only included in one of the six leading disaster mitigation frameworks. Finally, the widespread fear and uncertainty across all actor groups on how to manage COVID-19 deprioritized all components of the anti-SUDs transition. The combination of the growing, but structurally unsound movement, minimal preparation for waste management during a disaster, and both the novel nature of the virus and its quick and large-scale spread, resulted in a massively disrupted anti-SUDs transition. We predict that social and natural disasters will continue to result in hygiene waste unless actor-oriented and policy-based adjustments occur.

Chapter 6

Conclusion

1. Introduction

This dissertation analyzes current and potential sustainability transitions to waste-free systems, with a focus on elucidating the effectiveness of policy to foster such transitions. In the Introduction of this dissertation, I label new dimensions to the current sustainability transition frameworks. I reoriented the frameworks around who, where, when, and how, through numerous studies, a few of them exemplified in the previous chapters, on policy-based sustainability transitions to waste-free systems.

Those four dimensions are underpinned by the overarching ‘why’, which is the inherent harm that is unequally distributed in the waste system fueled by globalization, and the ‘what’, which is to achieve a waste-free system. The ‘who’ are actors who catalyze, propel, propagate, or stall policy-based sustainability transitions to waste-free systems. The ‘where’ is the spatial theory, the locations where such transitions are (or are not) occurring, and at what geographical scale. The ‘when’ is the temporality dynamics of the transition; how long the transition takes to materialize with an acknowledgment that there is no such discernable pattern at this time. Finally, the ‘how’ are frameworks – the multilevel perspective and leverage points – that propose processes to analyze and potentially guide transitions. Sustainability transitions are historically non-linear, complex, uncertain, and precarious (Köhler et al., 2019), all of which my co-authors and I affirmed in our thorough analyses of policy-based sustainability transitions to waste-free systems.

I developed these new dimensions through the specific lens of policy within waste-free sustainability transitions: the types of policies (Chapter 2: *Eliminating Single Use Disposable Foodware: An Emerging and Cascading Norm* (Heiges, 2023)), the effectiveness of a specific policy (Chapter 3: *Reaching for a Sustainability Transition in Berkeley, CA: Evaluating the Effectiveness of an Anti-Single Use Disposable Foodware Policy*), the ramifications of changing a downstream waste processing policy (Chapter 4: *A Recycling Reckoning: How Operation National Sword catalyzed a transition in the U.S. plastics recycling system* (Heiges & O'Neill, 2022a)), and the ramifications of pausing upstream waste reduction policies (Chapter 5: *Preventing the Influx of Waste in Future Disasters: Reflecting on COVID-19*).

Before summarizing the results of the studies that influenced the four dimensions of policy-based sustainability transitions, I want to provide some reflections on the methodologies used to conduct the studies featured in the four chapters as well as the short-form and informal papers that co-authors and I wrote during my dissertation tenure.

1.1. Methodologies

Throughout this dissertation, co-authors and I utilized a wide range of methodologies, depending on the research question and available data. We interviewed key actors to gain background, perspective, or insight. Some methodologies included a few numbers (e.g., a building’s diversion-from-landfill rate), a lot of numbers (e.g., commodity values over 10 years), and a lot of very big numbers (e.g., waste tonnages for a state or entire nation). I pored over news articles and industry trends. All these methodologies included reading the remarkable work that had already been done, and discovering how I could be additive, to move sustainability transition theory, discard studies, and waste-

free systems forward. This interdisciplinary approach gave unique and necessary insight into the waste-free systems transition phenomena because such phenomena are inherently interdisciplinary. No single methodology was appropriate, just as no single solution will transition us to waste-free systems. However, I and my co-authors specifically chose our methodologies because of the data available, our respect for the communities involved, and to provide actionable insight for researchers and practitioners.

1.2. Summary of the Chapters

In this section, I take you through the key questions and findings of the four chapters.

Chapter Two focuses on the emerging anti-SUD foodware norm through the policy mix framework integrated into the norm emergence theory. The paper answers the question: Is the anti-SUD foodware policy norm emergence gaining societal embeddedness? It is. The numerous policies, encompassing both creative and destructive mechanisms, with adequate but not particularly strong policy intensity, and a range of technological specificity, have resulted in what I feel is the anti-SUD foodware norm in the cascading norm phase. The next and final phase is norm internalization, when a norm becomes ‘taken for granted’. The stewards of the anti-SUD foodware norm have been a wide array of norm entrepreneurs, including activist organizations, government representatives, producers, waste service providers, food businesses, and innovators. The extent and type of contribution from each norm entrepreneur group has fluctuated over the years, including striations within each group. I take the background of norm emergence and norm entrepreneurs and focus it on a specific case to tease apart the theory and anti-SUD foodware norm. In this case, I examine Berkeley, California’s historic anti-SUD foodware ordinance through the policy mix framework – with a bit of analysis through policy intensity and technology specificity as well – as an added layer to the norm emergence theory. The ordinance had a strong mix of policies, including five of the seven creative policies and two of the four destructive policies. However, the policy intensity – or, structural strength – was stymied, in part because of how it was structured (no policy framework, no formally allocated roles), and in part, because budget, implementation, and monitoring (enforcement) were paused due to COVID-19. The second chapter was therefore an overview of all anti-SUD foodware policies, a demonstration that the anti-SUD foodware norm is in the ‘cascade’ phase of a norm emergence, and deep dive into one U.S. policy, and opportunities for the norm to develop further. The following three chapters focused on specific anti-SUD foodware policies at different geographical levels – from local to global – and how they have influenced the policy-based sustainability transition towards waste-free systems.

In Chapter Three, we focused locally, by deeply examining the Berkeley anti-SUD foodware ordinance through a longitudinal quantitative observational survey. Our aim was to assess the effectiveness of the ordinance, especially since it was designed to be a model ordinance for other jurisdictions to adopt. We assessed effectiveness through prepared food vendor (e.g., restaurant, grocery store; henceforth ‘vendor’) compliance with the policy. The study sought to answer three research questions.

- Research Question #1: What were the different rates of compliance with the Ordinance’s five legislative mechanisms?
- Research Question #2: How did the policy’s intensity influence the compliance rate?
- Research Question #3: Was there progress in greater adoption of the three niche-innovations over the four years?

Our findings were likely shaped substantially by the COVID-19 mandates and restrictions that influenced how food businesses could operate and what foodware (SUD or reusable) they could provide. Our data collection was from 2019 to 2022, with seasonal collection each fall.

Our results to *research question #1*, were mixed. At baseline (2019), vendors complied had high compliance rates with the policy mechanisms that were commonly adopted or expected by customers. That rate dropped during COVID-19 (2020) but had a strong bounce-back rate after COVID-19 (2021 and 2022). There were a few mechanisms that were easier for food businesses to adopt than others and those had a steady adoption rate over the four years. The mechanisms that were operationally challenging or expensive to adopt had declining, plateauing, or minimal compliance during the collection period. Finally, the policy mechanisms that were not allowed during COVID-19 had no rise in compliance during the four years.

The results for *research question #2*, were that while it is common for model policies to not include budgets, the lack of a specified budget and the fact that the budget was frozen during the four years meant that City staff did not implement or monitor the policy. Thus, there was minimal vendor compliance. Only one stakeholder – the City Manager – was tasked with implementation, and that department was already overburdened pre-pandemic, then like all City departments, was shifted to fully prioritize COVID-19 mitigation and relief efforts. Since the budget was not clearly defined and all City staff, budget, and resources in charge of compliance were reallocated due to reprioritization from COVID-19, as of late 2022, the City had not implemented or monitored the policy. This demonstrates low structural strength, thus a stymied policy intensity.

Results for *research question #3* – progress in the adoption of the three niche-innovations – were mixed. One niche-innovation had vendor compliance drop during COVID-19 but rebound during the following years. Another had a rise in compliance over the four years, so progress in the adoption of the niche-innovation rose. The final niche-innovation had a reduction in compliance over the four years, so there was no progress for the niche-innovation.

In Chapter Four, we scale up from the local to the national level, with a demonstration of the interconnectedness, obscurity, and precariousness of the global waste system. The research questions were: What has happened to the U.S. plastics recycling system since Operation National Sword? And, if the U.S. plastic recycling system entered a de-alignment from Operation National Sword, what might the re-alignment look like? We concluded that the U.S. plastics recycling system was de-aligned by the avalanche disruption that was Operation National Sword. Furthermore, while the resulting re-alignment period does not appear to have occurred, there are three emerging niche-innovations. If the niche-innovations were to emerge as part of the U.S. plastics recycling regime, this would demonstrate the possibility of multiple co-existing regimes, an unconsidered phenomenon in sustainability transitions literature. Furthermore, these three regimes would together create a more sustainable, just, and methodical U.S. plastics recycling regime compared to what was in place before Operation National Sword.

In Chapter Four, we go global, assessing the impacts of COVID-19 on waste generation and management. Our research questions were: What kind and how much waste was generated in the wake of COVID-19? How did COVID-19 impact the anti-SUD policy transition? And which actors and driving forces influenced the impact of the anti-SUD policy transition? We found that COVID-19, which we categorize as a disaster, resulted in a new form of waste: hygiene waste. This waste, comprised of SUD foodware and healthcare items, grew as a means to promote hygiene and prevent virus contagion. The pre-existing anti-SUD foodware policy transition was making progress pre-pandemic (which is also substantiated in Chapter 2 (Heiges, 2023)), but stalled during the pandemic. While there were anti-SUD

healthcare activities pre-pandemic, there were no policies already in place, so the pandemic did not influence a policy transition in that space. In both cases, four groups of actors made fear-driven decisions, especially with the absence of waste mitigation plans, that contributed to the proliferation of hygiene waste. Those actor groups were institutional, governmental, industry, and individuals. This examination of actors, decisions, policies, and resulting waste demonstrates that there are actor-oriented and policy-based opportunities to strengthen and harden the anti-SUD policy transition against future disasters.

2. A Social Imaginary

2.1. The Main Learning

Numerous learnings emerged with implications for the fields of sustainability transitions and discard studies, which I expand on below. However, I also had one singular but substantial learning that transcended theory and sector: in order to develop and eventually obtain a sustainability transition towards waste-free systems, we need a shared social imaginary. A social imaginary is an agreed-upon understanding, commonly referenced directly or indirectly, that is widely shared and holds a sense of legitimacy (Taylor, 2002). One example of this is the photographs of Earth, suspended in space, captured by U.S. cameras from the mid-1960s to early 1970s. As Jasanoff (2001) so poignantly notes, “The picture of the earth hanging in space not only renders visible and immediate the object of environmentalists’ concern, but it resonates with the themes of finiteness and fragility, and of human dependence on the biosphere, that have provided growing impetus for environmental mobilization since the 1960s” (p.310).

Like the image of earth fostering connectedness, social imaginaries are ‘paradigms-in-the-making’, meaning they are catalyzing a shift in how “social, cultural and political phenomena are understood and problematised” (Adams et al., 2015, p.16). A social imaginary differs from a norm, in that while they both have a degree of being taken for granted, a norm is a preexisting or emerging practice (Finnemore & Sikkink, 1998). A social imaginary is a desired end state(s). An emerging norm might be striving towards a social imaginary. A norm is grounded in today’s reality, a social imaginary is “[o]ur capacity to envision alternative social arrangements, new mechanisms of global governance, and processes of education and implementation that mesh the local and global in ways that foster justice and environmental resilience” (Conca, 2003, p.71). I propose we leverage a social imaginary to harness collective, appropriate, and timely action towards a recognized rising threat: waste-related pollution.

Presently, there is no social imaginary for waste-free systems. We would recognize such an imaginary because there would be a collectively identified ideal case, it would have a shared understanding across disciplines, it would be legitimized, it would unify actors, a minority group would not be able to have outsized impact on defining and guiding the imaginary, and anyone would be able to orient their position in the imaginary without receiving directions to do so (Taylor, 2002).

There is an excellent example of work that aimed to co-construct a social imaginary for life within the Intergovernmental Panel on Climate Change’s (IPCC) recommended global warming limit of 1.5 degrees Celsius, which is in accordance with the 2016 Paris Agreement. The *Rough Planet Notterdam 2045* (2020) is a detailed depiction of an imagined city in the Netherlands and how it has evolved to not exceed that global warming limit. It includes transportation (e.g., emissions-free trains, adding a carbon tax to flights, and sailing across the Atlantic), revitalization of the local economy (e.g., ‘demise of Big Retail’ and seasonal and low-carbon foods), and waste reduction (e.g., borrow hardware for repair, 3D printed apparel, and deposit schemes for reusable foodware). This is a prime example of Adloff and Neckel’s (2019) description and argument for the importance of social imaginaries: “it is to collective imaginations that we owe the futures of sustainability, i.e., our current images of possible futures to

come,” (p.1016). The specificity of this piece triggers the imagination to visualize a future desired state, thereby making the future desired state that much more possible.

A social imaginary must be co-created, approachable, adaptable, and not too prescriptive. It would unify action (Frank, 2010; Senge, 1990), create ownership in the action (Kirakosyan, 2017), and ensure equity in the action (Yepez-Reyes, 2018). A social imaginary is not like a form of wartime mobilization (Delina & Diesendorf, 2013) as it does not elicit fear, construct implicit dangers, create an enemy, or elucidate potential threats as tactics for mobilization (Kester & Sovacool, 2017). Furthermore, such a social imaginary would not override plurality (Taylor, 2002), participate in ‘print capitalism’, promote nationalism (Anderson, 2016), or be extractive (Liboiron, 2021). Instead, a social imaginary embodies a just, equitable, and healthful future that is participatory and galvanizing, giving a vision for the sustainability transition.

2.2.A Social Imaginary for Waste-Free Systems

To further strengthen the policy-based sustainability transition towards waste-free systems, I propose the creation of a social imaginary. I, however, am not so bold as to create that social imaginary; in fact, such a proposition would directly defy a core tenet of a social imaginary: co-creation. Instead, I propose an approach to creating the social imaginary of waste-free systems. This approach is to harness the learnings of the policy-based sustainability transition towards waste-free systems and the recategorization of sustainability transition dimensions: who, where, when, and how. In this approach, it is key to start with defining the underlying what and why. My studies propose that the ‘what’ is waste-free systems and the ‘why’ is inherent harm that is unequally distributed in part because of globalization. To build out the other four dimensions, I lean on relevant and emerging research in social imaginaries, social movements, sustainability transitions, and discard studies.

The who in the development of a social imaginary for waste-free systems would be an identification of the direct and indirect stakeholders, including their relevant power and interest, to ensure all are part of the co-creation process, in an equitable way (Fominaya, 2020; Newcombe, 2003; Senge, 1990). For more complete and representative participation, stakeholders must participate from the ‘inside’ (e.g., at the table) versus the ‘outside’ (e.g., protesting) (Fisher & Nasrin, 2020). Furthermore, there must be a structure for that participation to ensure all perspectives are represented equitably (Orr, 2016). However, it is crucial to note that participation does not mean influence (Betsill & Corell, 2001). Additional protocols for convening, engaging, and voting are necessary to change the inherently inequitable weights of influence (Corry & Reiner, 2020; Fominaya, 2020, 2022).

The where, in overly simplified terms, must occur locally and can be aided by global commitments. Here, the local level ranges from the town to the state or province; it is the space where the individual has agency to influence policy, infrastructure, innovations, and institutions. Neville and Weinthal (2016) note that sometimes it is important to re-envision the ‘local’, thus focusing on scaling down versus scaling up. This might include redefining ‘local’ with regard to the system’s boundaries. For instance, in the U.S., a city’s boundaries would be redefined to include the geographies in which the city’s waste is landfilled or incinerated, which is often outside of the city’s official boundaries. This can enhance political belonging, thus reinforcing legitimacy, justifying participation, and mobilizing and sustaining action (Neville & Weinthal, 2016). This is because, in part, starting locally can create inclusion without individualizing and without reinforcing harmful imaginaries (Tucker & Anantharaman, 2020). Also, creating a collective identity locally can create cohesion that might morph over time, but also whether the non-linearity and unpredictability of sustainability transitions (Fominaya, 2010a).

Furthermore, social movements often begin locally. Social movements, while not discussed much in this dissertation, can be a component of sustainability transitions. In fact, in many ways, social movements contain a similar structure and pathway as formulaically described for sustainability transitions through the multilevel perspective (MLP). Like a niche-innovation, local entities can be 'laboratories' to test and refine policy, innovations, and ideas, that morph into social movements (Moser, 2003). Those "small opposition groups (with the help of relevant experts) identify a problem and develop radically different perspective(s) on an issue not shared by the power elites and the general public" (Moser, 2003, p.131).

With scale comes difficulty in creating and maintaining a social imaginary. While there are, arguably, a few global social imaginaries (e.g., environmentalism galvanized through the imaginary of Earth suspended in space), they are contested and have become highly regulated. Therefore, the role of the social imaginary at the global level is not to create and maintain an imaginary, but instead to create the infrastructure, mechanisms, and actors to create and maintain core tenets of the imaginary. For instance, when it comes to human health, the World Health Organization is an institution of actors dedicated to transboundary support for disease prevention, eradication, and promotion of health for all (WHO Team, 2019). And the United Nations (UN) is a body of participating Member States to co-develop inclusive and sustainable growth (UN, 1945). In fact, the UN created the Sustainable Development Goals (SDGs), which are far more prescriptive than a social imaginary, but do provide a unifying end state for countries to mobilize around. So, there is groundwork in place for a global social imaginary to develop.

The when is immediate but done so in a methodical manner. As I write in the first half of 2023, we are in a unique and hopeful time to create a social imaginary for waste-free systems. The U.S. plastics recycling system remains in a post-de-alignment phase after the avalanche disruption of Operation National Sword (Chapter 4: Heiges & O'Neill, 2022a). There are three niche-innovations – zero waste and circular economy movements, expanding domestic processing, and eliminating problematic plastics – that are on track to potentially replace the unmethodical U.S. plastics recycling system that existed before Operation National Sword. Furthermore, the U.S. is still recovering and reorienting from COVID-19, which resulted in a new waste stream – hygiene waste – and prompted anti-SUD foodware policies to be paused or deprioritized across all jurisdictional levels (Chapter 5). Those policies are being reinstated and reprioritized, and new anti-SUD foodware policies are being introduced or enacted. The norm entrepreneurs ushering in these policies can learn from the strengths and shortcomings of one historic model anti-SUD foodware model ordinance (Chapter 3), and strategically steward policy that could harden the overall anti-SUD foodware policy transition (Chapter 2: Heiges, 2023, Chapter 5). The increased interest in anti-SUD foodware policy – and waste-free policy, in general – is exemplified by the United Nations Environment Assembly (UNEA) passing a resolution in March 2022 to create a global legally binding agreement by 2024 to address the full lifecycle of plastic (UNEA, 2022). This confluence of landscape and regime disruption; reinvigoration for, and a more detailed understanding of, anti-SUD foodware policy; an exponential increase of SUD foodware waste (Moss & Grousset, 2020; UN Environment Programme, 2018); and heightened global awareness and scrutiny of the destructive SUD foodware consumption culture (Kaza et al., 2018), demonstrate the unique time to create a social imaginary for waste-free systems. While SUD foodware is just one component of a waste-free system, it is a bellwether for what is to come and what can be possible.

Recognizing that now is a unique set of circumstances to catalyze and perpetuate sustainability transitions, it is important to mobilize methodically and equitably, and thus normalize action versus fear or complacency. As Wallace-Wells (2020) notes, normalizing action is a productive, and even necessary form of alarmism and alarmism is very prevalent in today's discourse on climate change. As discussed in Chapter 4, some of the largest issues in the U.S. plastics recycling system arose because it began and

expanded unmethodically (Heiges & O'Neill, 2022a). I, therefore, urge any action toward creating a social imaginary for waste-free systems to be methodical, to begin with a social imaginary.

Finally, the how. A social imaginary is the vision, co-created by stakeholders, requiring numerous components to develop. This vision must be compelling and grounded, even if it is envisioning a seemingly unobtainable future state (Kimmerer, 2013; Senge, 1990; Tucker & Anantharaman, 2020). One potential approach to creating a social imaginary is radical incrementalism. Radical incrementalism is the process of implementing small, incremental changes with routine evaluation to maximize effectiveness. However, radical incrementalism can take a long time to develop and realize gains. This might make it a relatively more just, methodical, and viable process (Anantharaman, 2023), but it will not happen with urgency and might be deprioritized amid extenuating circumstances, like a country adopting a new policy (Chapter 4: Heiges & O'Neill, 2022a) or a global pandemic (Chapter 5). One example of proposed radical incrementalism, by Anantharaman (2023), is to recapture and redistribute power for waste workers locally and incrementally through 'recursive empowerment'. This process would result in more equitable and safe labor practices for waste workers, where waste workers feel both included in the process and empowered by the result, and such ingrained political modes of silencing are eroded.

Another process is through social movements. Social movements are coordinated, productive actions (Fominaya, 2020). Social movements often strive to realize a future state (Fenton, 2007), and I argue that the described future state can be a social imaginary. A social imaginary gives a social movement a future worth striving for, and new credibility (Fenton, 2007). A social movement can turn a social imaginary from a vision into action (Fominaya, 2022); it can create the 'collective belonging' necessary to progress a niche-innovation, and sustain it over time (Fominaya, 2010b; Moser, 2003).

Regardless of the base process – radical incrementalism, social movements, or another approach – to assess progress toward the social imaginary, it is important to have goals, benchmarks, and timelines (Betsill & Corell, 2001; Moser, 2003). This iterative and reflective process ensures a feedback loop for evaluation and adjustment, thereby promoting the long-term viability of a solution, adapting to unintended consequences, and not being implemented in isolation (Meadows, 2008).

2.3. My Dissertation and a Social Imaginary

Over my doctoral tenure, all studies conducted contribute to substantiating the need for, and elucidating potential avenues to, a social imaginary for waste-free systems; the desired end state for a sustainability transition. The chapters of this dissertation provide insight into strategies for the sustainability transition to obtain that social imaginary.

In Chapter 2, I demonstrate potential policy approaches, their strengths and shortcomings, to local, federal, and international progress towards robust and supportive waste-free systems. The policies are creative and destructive, fostering innovation and eroding incumbents; there is an emerging norm of anti-SUD foodware and the learnings and successes are translatable to larger waste-free efforts. In Chapter 3, co-authors and I dive deeply into a local anti-SUD foodware policy with multiple policy mechanisms. This policy, like social movements, came from community-driven development. We discuss the importance of one community actor in particular – prepared food vendors – in determining the effectiveness of the policy. This longitudinal study, therefore, demonstrates local action, the role of actors to impede or spread action, and the proliferation of action elsewhere. In Chapter 4, we scale up, taking a regional perspective centered on the U.S. (Heiges & O'Neill, 2022a). We underscore how a policy from one nation can have a global impact and completely disrupt a regional system. That shows that policy can be a means of interconnectedness between actors and sectors, regardless of the

geography and sector. Furthermore, this examination proposes a regional social imaginary, giving three prospective avenues for a more environmentally sound U.S. plastics recycling system. So, what might be devastating and disruptive in the short term could have long term positive impacts. Finally, in Chapter 5, we again discuss the role of actors in policy, however, this time through the examination of numerous actors and their disparate actions to cause collective impediment toward the anti-SUDs movement. Additionally, we discuss the importance of preempting landscape changes and integrating policy to strengthen a sustainability transition against such changes and progress in a sustainability transition.

3. Conclusion

3.1 Contributions and Recommendations

Co-authors and I conducted studies to inform and further two distinct fields: sustainability transitions theory and discard studies. Sustainability transitions theory analyzes the key attributes and conditions that catalyze, perpetuate, and inhibit transitions toward more sustainable states (Köhler et al., 2019). Discards studies are the interdisciplinary field that centers waste and examines its highly interrelated components, such as economics, behavior, labor, and infrastructure (Liboiron, 2018). Through deeply examining a few keystone policies in waste at different scales and how they influence a sustainability transition, my co-authors and I aimed to further both fields in material ways.

Sustainability Transition Theory

Our first contribution, and what has already been discussed in this Conclusion, is the recategorization of sustainability transition theory frameworks. This contribution is of note because the field is emerging, so it is important to have a dimension mechanism that succinctly outlines and aligns the current frameworks, demonstrates research gaps in certain dimensions, fosters the inclusion of new research, and gives direction, that is not overly prescriptive, to the field. It is meant as a means to coalesce and stimulate researchers.

One of our more hidden, yet exceedingly informative, contributions to the field is the inclusion of non-traditional actors and their role in sustainability transitions. Waste service providers (e.g., haulers) are not often part of the discourse on actors who positively or negatively influence a transition. This is not surprising as their role, while public-facing, is meant to be hidden from the public; their goal is to make their services distant from society and to remove society's waste. Providers are therefore often not considered in policy (Allen, 2023), innovation development (Allen, 2022), or infrastructure (Schultz & Heiges, 2023). While they are part of the underpinnings of societal hygiene, their labor was not considered essential until COVID-19 (Chapter 5). We elevate their complicated and essential role in both supporting and inhibiting sustainability transitions (Heiges, Jackson et al., n.d.; Chapter 4: Heiges & O'Neill, 2022a).

The third contribution is our emphasis on policy as an essential component to catalyze, perpetuate, or inhibit a sustainability transition. Policy is part of current sustainability transition theory. However, it is considered more of an occasional component with fluctuating influence, versus a key requirement every time (Köhler et al., 2019). Policy can support niche-innovations (Köhler et al., 2019), formalize practices (Clapp & Swanston, 2009), codify a norm (Finnemore & Sikkink, 1998), or legitimize niche-innovations on a global scale (Dauvergne, 2018a; Rosenbloom et al., 2020). Policy can also perpetuate inequalities and reinforce destructive systems (Fominaya, 2022; Tucker & Anantharaman, 2020). Regardless of its role, policy does influence a sustainability transition and therefore should receive more examination than already received through the subfield of sustainability transition policy.

Our fourth contribution to sustainability transition theory is the potential for multiple, co-existing regimes, which would be an additional pathway in the MLP transition framework. The MLP, arguably the preeminent sustainability transition framework of the time, identifies the various heuristic levels – niche-innovation, regime, and landscape – each comprising different powers and conditions that influence a sustainability transition (Geels & Schot, 2007). The regime is the stable societal condition that a sustainability transition seeks to disrupt. We feel that the MLP does not account for the potentiality of multiple co-existing regimes to emerge as part of a sustainability transition. The MLP instead discusses how a niche-innovation will replace a regime (e.g., de-alignment and re-alignment pathway and technological substitution pathways) and while we agree that the niche-innovation will replace the regime, we argue that there can be multiple niche-innovations that collectively replace the regime (Chapter 4: Heiges & O'Neill, 2022a).

Discard Studies

Our contributions to discard studies are prominent in each of the chapters. In Chapter 2, through a policy analysis framework (policy mix), I outline an emerging norm – anti-SUD foodware – and how it is firmly in the ‘cascade’ phase, thereby increasing its everyday relevancy and influence, but not yet taken for granted. This conclusion was derived, in part, through the policy mix framework that demonstrated the gaps and effectiveness of anti-SUD foodware policies, thus informing direction to further the policy-based norm. There was no such framing of the proliferation of anti-SUD foodware as an emerging norm, nor a policy gap and effectiveness analysis through the credible policy mix framework. As local jurisdictions in the global sociopolitical landscape aim to adopt anti-SUD foodware policies, this analysis can hopefully help inform such policies to ensure they are effective. The next step is to also ensure the policies are just and equitable.

In Chapter 3, we give a rare contribution to discard studies: a rigorous study on the effectiveness of a policy (Diana et al., 2022). While this chapter focuses on a local policy, in combination with Chapter 2, we give evidence-based insight into policy mechanisms for myriad actors to foster waste reduction efforts. This type of insight is especially important as the UNEA begins to negotiate components of the global plastics treaty. Presently, it is possible that the treaty would require member nations to adopt their own strategies, including policy mechanisms, to achieve the treaty’s goals. Chapter 3 can inform what types of policy mechanisms the U.S., its states, and its municipalities should adopt for the greatest effectiveness.

Chapter 4 proposes a more sustainable future state for the U.S. plastics recycling system. In this chapter, through the proposed co-existing regimes, we provide discard studies with the potential and framing of more methodical, sustainable, and just U.S. plastics recycling system regimes. These emerging regimes, not unlike a social imaginary, give the field guidance on how to allocate resources – from the actors to the policies – to support such growth.

Finally, in Chapter 5, we uniquely name an unprecedented waste stream in its scale and harm that arose with the COVID-19 disaster: hygiene waste. By combining SUD foodware and healthcare waste into a single entity, we help emphasize the harms associated with the material, and their predictable generation in hygiene-relevant disasters. Our insights thereby support actor-oriented and policy-based solutions to curb the generation of such material in future disasters.

3.2. Remaining Questions

As I reflect on the studies we conducted and the current state of the policy-based sustainability transition towards waste-free systems, a few lingering questions remain. First, acknowledging the transition as a whole, and considering the creation of a social imaginary, is it possible to incorporate

reciprocity into production and consumption models? If the existing models that expose harms are grounded in extraction, what would a model grounded in reciprocity include and what are the steps to embody it? Similarly, much of our work has focused on the sustainability components of a transition, with not enough emphasis on the equity components of a transition. How can we ensure that the transition towards waste-free systems is equitable for all human and more-than-human stakeholders?

Additional reflection on the transition itself prompts the reiteration of a question long disputed and unresolved in sustainability transitions: How will we know if a transition is effective? Here, effectiveness is different from 'complete', in that a transition can secure its outputs, but is ineffective in reaching its goals or outcomes. Are there data-driven indicators that would create a feedback loop to assess the effectiveness of a policy-based sustainability transition towards waste-free systems? Or are there other barometers to engage for such an assessment?

I firmly believe that we must form a social imaginary for waste-free systems and that policy is necessary to realize the imaginary. However, I am not as sure about our current approach through both material-specific waste reduction (e.g., focusing only on plastics) or the actors involved (e.g., mostly activist organizations with minimal academic and waste service provider involvement). It is not that I am a skeptic of this approach, instead, I feel it is important to better understand if this strategy is effective and what changes we should or should not make as a result. Many of those identified components could be considered components of a social movement. If someone were to argue that we are undergoing a social movement to waste-free systems, I would be interested to hear their analysis on the effectiveness of the one-material and specific-actor approach.

A final lingering question pertains to the role of climate anxiety. As climate anxiety becomes more prevalent among climate scientists and activists, how can we harness such anxiety toward action while preventing emotional harm? How can we identify such anxiety early to support those with a higher predisposition to it, to mitigate it? If this is a work hazard, how can we ensure we maintain the health and wellness of people doing exceedingly important work?

3.3. Parting Thoughts

In this Conclusion, while I provide a summary of the chapters as well as our research contributions to and recommendations for sustainability transition theory and discard studies, I push beyond that. I propose an overarching concept of a social imaginary as a key tenet to advance a policy-based sustainability transition towards waste-free systems. Through the recategorization of sustainability transition frameworks, after noting the why (inherent harm distributed unequally) and what (towards waste-free systems), I describe the who, where, when, and how to create a social imaginary for waste-free systems. The frameworks and theories leveraged to create that argument were the ones leveraged in our studies, except for social movements. Social movements were another concept introduced for the first time in this dissertation in this Conclusion. Social movements, while integral to discard studies, are less prominent in sustainability transition theory. This Conclusion thereby provides an opening for greater research on and reflection on the confluence of social movements and sustainability transitions.

I want to close with the parting thought of possibilities. There is so much waste. We can let the enormity of the problem stymie us, or we can let it galvanize us into action. Every action towards a waste-free system matters, regardless of the timing, scale, process, or actors. It is possible that we can coalesce those actions under a social imaginary, making the transition sustainable and just. I plan to continue orienting toward possibilities of sustainability transitions to waste-free systems.

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