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Removing barriers to plastic waste valorisation in Africa: Towards policies for value creation and capture in business ecosystems

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Abstract

Stimulating plastic waste valorisation is suggested as an important way to address the growing waste problem in low-income countries. However, policy interventions have not led to substantial waste valorisation, and the reasons for this have not been thoroughly analysed. We address this through a qualitative study of plastic waste in urban Zambia, which is representative of the policy and practice challenges in African plastic waste management. Using extensive data gathered through interviews, site visits and stakeholder meetings, we first conduct a business ecosystem analysis which provides a holistic view on value creation, capture, and destruction processes across all actors involved in the plastics lifecycle. Next, we map the barriers to value creation and capture by the system's main actors. Aggregation of these barriers reveals a low-value trap, in which individual actors are disincentivized to increase waste valorisation activities. Finally, we analyse the reasons why policies aimed at waste valorisation have failed to break through this status quo. We find that policies have insufficiently addressed the barriers that keep the low-value trap in place. Hence, they have not acted effectively on the root causes of systemic stagnation. By combining a business ecosystems analysis with an identification of barriers facing the individual actors in that ecosystem, our study is able to show why substantial plastic waste valorisation has not emerged despite policy incentives. Our analysis points toward concrete policy actions aimed at value redistribution and value increase, as key leverage points in the system to increase valorisation.

KEYWORDS

business ecosystems, plastic waste valorisation, policy, value capture, value creation

1 | INTRODUCTION

There is a growing concern about plastic waste entering our environment, voiced widely in media and scientific literature (Ayeleru et al., 2020). Low- and middle-income countries (LMICs) are the main

entry point of plastics in the environment worldwide (Gall et al., 2020). Specifically for the African continent, plastics damage and disrupt natural ecosystems and severely affect crop yields, fisheries and thus food security as well as human health (UNEP, 2018). Due to population growth, urbanization, changing consumption patterns

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and economic growth, plastic waste is increasing rapidly in these countries, while resource constraints, capacities and competing goals of governments continue to prevent effective (plastic) waste management (Bauer, 2020; Sadan & de Kock, 2021). Currently, a very small fraction of plastics generated is recycled.

Recent literature on plastic waste management in African LMICs suggests that transitioning from a linear 'take-make-dispose' system to a more circular alternative, focused on waste valorisation, can be a potential solution for the growing plastics problem (e.g., Donner et al., 2021; Ferronato et al., 2019). Plastic waste valorisation refers to the conversion of waste materials into valuable resources, thereby creating economic opportunities while mitigating negative environmental impacts. Beyond playing an important role in the transition to more sustainable waste management practices, plastic waste valorisation opens up opportunities for job creation, therefore improving living conditions, thus contributing to poverty alleviation (Godfrey et al., 2017).

Traditionally, waste management systems are not designed for profit, but provided by local authorities as a basic service for a clean and healthy environment for its constituents. The shift towards waste valorisation requires private and informal sector actors to set up businesses for waste collection, treatment and valorisation. It also requires new linkages between existing actors, for example, when the plastic waste of one actor constitutes the input for another (Kanda et al., 2021; Pieroni et al., 2019). Thus effective plastic waste valorisation requires the alteration and emergence of new value chains, leading to an altered plastic waste business ecosystem (Peltola et al., 2016). This will not arise spontaneously but requires policies and regulations that dissuade linear make-use-dispose behaviour while creating opportunities for actors to create and capture value from waste (Peltola et al., 2016). Unfortunately, recent policy efforts in various sub-Saharan African countries (UNEP, 2021), have not led to the necessary improvement in waste management through increased waste valorisation (Olatayo et al., 2022). Waste policy in many African countries is still mainly aimed at collection and separation, rather than on the upstream (e.g., reduction of virgin plastics) or downstream (e.g., promotion of value creation and capture from waste) parts of the value chain (Deme et al., 2022; Sadan & De Kock, 2021; Schröder et al., 2023).

Yet, even in countries with upstream and downstream policies, plastic waste valorisation has not emerged as expected (Singh et al., 2023). This study aims to probe the reasons for this. It addresses the research question: *Why has substantial plastic waste valorisation in sub-Saharan Africa not emerged in response to policy incentives, and what could more effective policy inducements look like?*

Our study is not the first to engage with policy surrounding plastic waste valorisation, but existing literature shows certain limitations. First, existing studies on plastics policies mainly focus on global, national and/or regional policy frameworks and agendas, rather than on how these affect waste actors in practice. They might highlight where a country lacks policy (e.g., Olatayo et al., 2022), but fail to trace the exact effect of policy on an actor's potential for value creation and capture. This is problematic, since plastic waste reduction hinges on the success of actors in establishing a thriving plastic waste valorisation system. Second, studies that have focused on value creation and capture logic of plastic waste actors mainly

study the business models of individual actor groups, such as informal sector participants (Aparcana, 2017; Fei et al., 2016; Gall et al., 2020; Xie & Martin, 2022), or aggregators (Barnes et al., 2021; Ezeah et al., 2013; Godfrey et al., 2017; Higgs & Hill, 2018), instead of studying interactions between these different types of actors. Yet, these interactions are critical, since the shift towards more circular forms of waste management will require the value chains of multiple actors to become connected, requiring greater collaboration (Kanda et al., 2021). A first step in this direction was taken by Peltola et al. (2016), who investigated value creation and capture in waste business ecosystems, but this study did not focus on plastic waste, nor did it address how policy influences the value creation and capture trajectories. Thus, although some studies indirectly indicate some relevant policy barriers for value creation and capture, they do not build an overarching picture of how policy affects value creation and capture trajectories of actors in the plastic waste business ecosystem, while this is essential in order to understand why plastic waste valorisation is not emerging despite policy incentives.

Therefore, this study aims to analyse how policy affects plastic waste valorisation, using a meso-level business ecosystems perspective as its starting point. This perspective allows us to combine an analysis of the key characteristics of the waste system as a whole, and the roles and positions of individual actors in it, navigating between these two levels as required. To answer the research question, we conduct a qualitative analysis of urban Zambia's plastic waste ecosystem, a representative case in respect of the policy and practice challenges of plastic waste valorisation in Africa, where both upstream and downstream plastic policies have been implemented (Singh et al., 2023). We map Zambia's urban plastic waste system and then study barriers to value creation and capture mechanisms faced by each actor group in that system. We explore how these barriers are interconnected and how they reinforce each other's negative effects. After this, we analyse the government's policies aimed at encouraging waste valorisation in Zambia and see if they effectively tackle the root causes of these barriers. This analysis reveals areas where policies may not align with actual problems, offering valuable insights for improving the waste valorisation system. The main contribution of this approach is therefore that it enhances the value of extant business ecosystem research through expanded policy relevance.

In Section 2, literature on value creation and capture in business ecosystems is introduced as well as more specific literature on plastic waste valorisation systems and policy interventions in Africa. Section 3 presents the methodology. Section 4 contains the results of our empirical study. The final Section 5 draws out the wider contributions and implications from the case, suggests limitations and future research directions, and provides conclusions.

2 | LITERATURE BACKGROUND AND CONCEPTUAL FRAMEWORK

2.1 | Plastic waste in urban sub-Saharan Africa

Urban household plastic waste handling and its attendant problems are similar across sub-Saharan Africa and other LMICs (Ezeah

et al., 2013; Ayeleru et al., 2020). The main characteristics are well-known from existing studies, so the explanation is kept brief here. In most urban areas at least five waste actor groups are actively involved in waste disposal and valorisation, among which many necessity-driven informal activities. Additionally, national and local governments, donors and NGOs influence the value chain, but are not directly part of it (Korsunova et al., 2022). Plastics waste generated by households gets mixed up with other types of waste such as, organics, metals and glass. Households dispose this mixed waste via illegal dumping, skip-bins, or collection services. Only in some better-off urban areas, formal mixed waste collection services by public or private collectors are available against a monthly fee. Separated waste collection services hardly exist, but informal waste collection is undertaken by individuals going door-to-door collecting, for example, paper or glass waste from households, institutions and so forth, using small carts (Ezeah et al., 2013). Informal waste pickers also collect specific types of waste with residual value from open dumpsites or landfills and sell these to middlemen (Gall et al., 2020). The most common middlemen are aggregators, who purchase materials from waste pickers, resell among each other and eventually sell in bulk to the processing industry (e.g., recyclers, exporters). Other upcoming intermediaries are buy-back centres and waste transfer stations (WTSs), who purchase valuable materials from waste pickers and collection services, and sometimes households (Barnes et al., 2021). The materials are aggregated and sold to the recyclers.¹ Some recyclers make finished goods to be sold to end-customers, while others make granulates or pellets to be sold to manufacturers. However, the bulk of plastic waste generated ends up in landfills or in the public environment; only approximately 4% is recycled (UNEP, 2018).

2.2 | Plastic waste valorisation policies in sub-Saharan Africa

Attention to waste valorisation as a potential solution for Africa's fast-rising plastic problem is of very recent origin. Excluding purely technical studies, which rarely focus on LMICs, we can classify the literature to date into studies with a macro and micro focus. The former predominantly focus on national policy interventions (e.g., Deme et al., 2022; Hira et al., 2022; Kataki et al., 2022; Olatayo et al., 2022; Schröder et al., 2023; Xie & Martin, 2022). By contrast, studies that take a micro-perspective zoom in on one or two specific actors in the plastic waste system (e.g., Barnes et al., 2021; Ezeah et al., 2013; Gall et al., 2020, and Godfrey et al., 2017). We briefly review these two literature sub-sets, and then proceed to outline how we will try to overcome the limitations in these studies through the conceptual approach taken in this article.

Macro studies stress the importance of moving away from the linear 'produce-use-dispose' model towards circularity in order to prevent plastic pollution. These studies argue that achieving this shift necessitates a comprehensive set of interventions across the entire waste value chain. A World Bank study (Xie & Martin, 2022) waxes particularly big, presenting a large number of measures and

interventions to improve governance, drive behavioural change and stimulate investment. Other authors with similar views criticize African governments' recent move to focus selectively on single-use plastic bans and plastics levies (Deme et al., 2022; Singh et al., 2023). Yet, these policy studies also frequently point out problems like limited capacity, financial constraints, and lack of policy coordination within African governments. This signals a gap between their ambitious policy suggestions, which require substantial resources, and the harsh realities on the ground. They often lack a practical perspective on how to implement their recommendations effectively, missing crucial insights needed for policymaking and self-assessment of their feasibility. Some studies even move straight from signalling implementation constraints in African governments to the design of a hugely ambitious policy agenda which does not align with the implementation capabilities required for that agenda (e.g., Schröder et al., 2023).

The big gap between what is desirable and what is possible is brought out in more critical investigations. For instance, Muheirwe et al. (2022) observe that the ambitious policy agendas that are drawn up for least developed countries are often modelled on approaches taken by western countries, whose socio-economic context and capacities are completely different. This can lead sub-Saharan governments to adopt policies and strategies that are highly resource intensive, thus increasing their foreign debt burden, while they offer limited scope for bringing effective solutions locally (Bjerkli, 2015). Questions about which interventions to prioritize and how local constraints can be successfully navigated while taking advantage of possibilities afforded by the local context, are not sufficiently addressed in these studies. Yet, according to Nijhof et al. (2022) such questions are crucial in situations that require systemic market-transformations. Although Nijhof et al. (2022) point does not address transformations in LMICs specifically, a focus on policy selectivity is arguably all the more crucial for such countries, in order to avoid underfunded policy systems and weakly functioning institutions from becoming overwhelmed.

Micro studies addressing plastic waste valorisation address the barriers that one or two specific actors experience, including policy-related and behavioural factors. Thus, these studies look inside out, whereas the policy studies look outside in. Examples are Godfrey et al. (2017) who focused on the potential for cooperatives in the waste sector; Gall et al. (2020) about the integration of informal sector waste pickers; Akinboade et al. (2012) about value creation through social business models; Barnes et al. (2021) on the potential for buy-back centres in connecting formal and informal actors; and Kolade et al. (2022) with a focus on digital innovators. The findings and recommendations from these studies often fall short in addressing the current challenges. Effective plastic waste valorisation means that the existing business models of individual actors in the system will be disrupted because circularity affects the way the entire value chain operates (Kanda et al., 2021). Therefore, in-depth analysis and proposed business model solutions for individual actors alone are insufficient. The studies may not effectively address the systemic transformation that involves reconfiguring actor functions and relationships. Recommendations for individual actor business models, without considering these broader implications, may result in incremental or partial solutions.

Concluding, existing studies address waste strategies in LMICs either from a too distant meta policy viewpoint, or from a too limited micro-actor perspective. Both are insufficient in their own way, given the fact that plastic waste valorisation, which is a core ingredient of the successful introduction of circularity, requires systemic transformation involving new or transformed inter-actor interactions (Kanda et al., 2021). What is missing are studies that take an in-between, 'meso' position to connect the two. To our knowledge, the only study to focus on inter-stakeholder relations is Peltola et al. (2016), which provides valuable insights into shifting value creation and capture with circular practices through a business ecosystem analysis. However, that study stops short of using this analysis to explore how policy impacts actors' value creation and inter-stakeholder interactions. A business ecosystem analysis alone is evidently still insufficient for this purpose. In short, what is still lacking is an analysis of the practical relevance and chance of success of policy measures from the grounded reality of the various inter-related actors in the plastic waste system who must change. This involves careful policy prioritization to optimize limited resources and capacities, prevent fragmentation, and drive strategic change by incentivizing ecosystem actors. We propose a conceptual approach that should help to make progress in this direction.

2.3 | Conceptual framework

The starting point for this article's approach is that plastic waste valorisation requires a well-functioning business ecosystem wherein all participating actors benefit from changing their practices and operations towards valorisation, that is, the system should facilitate opportunities for gainful value creation and value capture. To understand why policies to stimulate waste valorisation have failed to achieve this, one should not start analysing from the perspective of policy; nor from the perspective of individual actors' business models, as previous studies have. This article's alternative approach begins with the business ecosystem perspective, which considers all stakeholders and their value creation and capture process in relation to an overall value proposition (Adner, 2012, 2016). In other words, it studies a system's aggregate value creation and capture logic, while also tracing how and why interactions between different actors take place to create value for end-users/customers (Leviäkangas & Öörni, 2020). Thus, inspired by works like Peltola et al. (2016), Donner et al. (2021), and Ferronato et al. (2019), in our approach we emphasize stakeholder value creation and capture within the plastic waste ecosystem as the key focus for circular approaches to plastic waste management in sub-Saharan Africa. Low-income contexts are rich in circular practices (Korsunova et al., 2022), but these are mainly conducted out of economic necessity. Thus, to understand why policies to encourage plastic waste valorisation in these environments have not led to results of significant magnitude, there is good reason to zoom in on stakeholders' constraints to create and capture economic value from plastic waste.

Our approach consists of three steps that effectively combine an ecosystems analysis similar to Peltola et al.'s study (2016) with a policy effectiveness assessment, as follows:

1. *Step 1: Mapping the plastic waste ecosystem, and analysing the actor interactions in it.* First, we need to understand how the actors in the system interact with one another. Specifically, we must investigate how each actor, through its role and interactions with others, creates and captures value in the current system. The system should afford a healthy balance between the value creation efforts and the value capture for each actor. This part of the analysis is documented in Section 4.1 and follows Peltola et al.'s (2016) methodology for business ecosystem assessment in the waste sector.
2. *Step 2: Exploring actor-specific barriers to expanding waste valorisation activities.* This second part of the analysis is an intermediate step, setting the stage for the subsequent policy effectiveness analysis. It digs deeper into the underlying reasons why individual actors are unable to capture sufficient economic value. This includes a visual cause-and-effect analysis, providing a powerful insight into how barriers among different actor groups interact and how this leads to system stagnation. This part of the analysis is documented in Section 4.2.
3. *Step 3: Analysing policy (in)effectiveness.* In this last step, we utilize the cause-and-effect analysis to evaluate to what extent existing policies attempt to address the identified barriers. This is accomplished by mapping the policy measures onto the diagram to determine if they effectively tackle any of the identified obstacles. Various scenarios are conceivable that could hinder policy effectiveness: some policies may not address the critical barriers mentioned by the actors, while others may only deal with minor issues that do not significantly hinder the system's improvement. Based on this analysis we can plausibly point to major reasons for the ineffectiveness of current policies, while providing a tool that can be used to determine more effective policy action trajectories. This third part of the analysis is documented in Section 4.3.

3 | METHODS

3.1 | Case study design

A single case study design was chosen as the research method (Yazan, 2015). Studying a single case allows for an in-depth examination of a phenomenon that is challenging to achieve with other methods (Ozcan et al., 2017). It helps gain a deep understanding of complex phenomena, especially when they are closely tied to their local context, a research approach frequently used in LMICs (Peltola et al., 2016).

Zambia was selected for three reasons. First, in terms of waste management system development and GDP per capita, Zambia mirrors the regional average in Southern Africa (UNEP, 2018). Second, like many other countries in the region, Zambia is grappling with growing volumes of household waste due to rapid urbanization, population growth, and economic development, all without adequate disposal solutions. Third, the first author was lead scientist in a research team executing a large project commissioned by UNEP, in collaboration with the Zambian Ministry of Technology and Science to develop a circular roadmap for plastic waste management, giving her and her team the opportunity to collect a large and detailed data set.

3.2 | Data collection

For our study, we draw on data from the large UNEP project, herein the primary empirical data was gathered by means of a standardized household survey and a set of semi-structured interviews with other ecosystem actors. The data collection period covered the whole of 2021 (phase one) and the first quartile of 2022 (phase two). Information was gathered from all important actor groups in the ecosystem.

For the household survey, 273 households were covered across different income classes in three major Zambian cities: Lusaka, Kitwe, and Livingstone. Local NGO staff conducted face-to-face structured questionnaires in local languages, ensuring a strong response rate. Questions focused on waste characterisation, collection services and fees, disposal mechanisms and willingness to separate. From this large data set, an understanding was gained about the why's and how's of common waste handling practices from the household perspective, and the challenges and possible opportunities these practices present for waste valorisation. The household survey data were a prerequisite for the first step of our analysis, as outlined in Section 2.

Perspectives from the other actor groups (e.g., waste collectors, waste pickers, aggregators, recyclers, governments, NGOs) in the plastics waste system were gathered by the first author and her research team through in-depth semi-structured interviews. These were aimed at constructing a picture of the structure and process of plastic household waste management in urban areas in Zambia and the value creation, capture and destruction in the current plastic waste system. These data likewise fed into step 1 of the analysis. The same interviews also addressed crucial data requirements for step 2 in the analysis: the barriers experienced by the actors that affect their ability to create or capture value, and the perceived reasons for these barriers. This information contributed to the cause-and-effect analysis, helping to grasp the interconnectedness of barriers and their impact on actor roles and relationships. Candidates for these in-depth interviews were initially selected by the Zambian Ministry of Technology and Science in consultation with the Ministry of Local Government. Other interviewees were identified by using the network of the research team, internet searches and snowballing from interviewees already identified. The first author led the interviews, supported by the research team, which took place at the interviewee's place of business, ranging from formal offices for companies and institutions to dumpsites for the informal sector. Interviews typically lasted between 1 and 2 h.

The second phase of data collection aimed to validate initial findings from the survey and interviews while delving deeper into the causal relationships among value mechanisms, challenges, and barriers. This involved three stakeholder meetings held in Lusaka, attended by multiple actors from each group, where preliminary results were presented, verified, and adjusted as necessary. Additionally, this phase encompassed more extensive interviews with each actor group, group discussions, on-site visits, observations, and presentations. Specifically, we conducted visits to three recycling plants, six middlemen (including aggregators, WTSs, and buy-back centres), and four waste collectors, facilitating discussions with workers in their local environments. These interactions enhanced data triangulation

TABLE 1 Data collection per actor group, tools used and number of data points.

Actor groups	Tools used	Data points
Households	Structured interviews	273
Waste collectors (formal and informal)	Interviews and learning visits	5
Waste pickers (informal)	Interviews and learning visits	3
Middlemen (waste transfer stations, buy back centres and aggregators)	Interviews and learning visits	8
Recyclers	Interviews and learning visits	5
Government departments	Interviews	12
NGOs	Interviews	4
Waste consultants	Interviews	3
Stakeholder meetings with 20+ private and public parties active in waste (e.g., waste collectors, recyclers, consultants, governments, NGOs)	Stakeholder meeting	3
Total		318

and overall quality of findings. For a complete summary of data points, consult Table 1.

The additional data required for the policy effectiveness analysis in step 3 entailed information gathered from the interviews with government actors about the applied plastic waste policy instruments, projects and interventions in Zambia, as well as secondary information drawn from relevant policy documents.

3.3 | Data analysis

Data analysis involved three steps: analysing actor interactions and deriving actor-specific barriers (step 1) and constructing a cause-and-effect diagram of the barriers at system level (step 2), and policy effectiveness analysis (step 3). For step 1, we analysed the key actors in the plastic waste business ecosystem and mapped the structure and process of value creation, capture and destruction, following the method of Peltola et al. (2016). The data from the household survey were analysed in Excel. This involved mainly the production of simple frequency tables to derive common household practices. The data from the in-depth interviews were analysed by means of manual coding, since the numbers in each actor category were limited. The transcribed interviews were scanned for keywords and phrases addressing practices of value creation and capture, barriers occurring in these processes, and causes for these barriers, and recurring patterns were derived. The members of the core research team discussed and calibrated their perspectives emerging from this process to minimize subjectivity. The analysis in step 3 comprised the derivation of a coherent table of main plastic waste policies and policy instruments/interventions aggregated from the interviews and policy documents

TABLE 2 Value creation, capture and destruction mechanisms for each of the key actors in the plastic waste business ecosystem.

Value creation		Value capture	Value destruction
Households			Mix various types of waste (e.g., organics, paper, plastics) in the same bin, lowering the potential value by contamination
Waste collectors	Offer waste collection services to households	Receive monthly payments from households and/or are (partly) financed by local authorities	Waste is not separately collected and dumped at dumpsites, reducing the potential value in the plastics
Disposal site operators	Offer a legal way to dispose of waste	Receive payment per truck or per ton of waste dumped	Waste is buried on top of each other, limiting collection window, and diminishing the potential value of the plastics
Waste pickers	Pick plastics from dumpsites thereby create potential for the plastics to be valorised again	Receive a payment per kilogram depending on cleanliness and polymer type from middlemen	
Middlemen	Aggregate specific plastic polymer types	Receive a payment per kilogram plastic from other middlemen or recyclers	
Recyclers	Process the plastics to flakes, granulates or new products	Receive a payment from selling flakes or granulates to manufacturers or a payment per product when selling finished goods	

and applying this to the cause-and-effect diagram of valorisation barriers, as described in step 3 in Section 2.

4 | RESULTS

4.1 | Analysing actor interactions

The plastic waste ecosystem in Zambia can be divided into three parts: the formal collection and disposal system comprising of households, private, informal and public waste collectors; the valorisation system comprising of informal sector (e.g., waste pickers, middlemen) and private companies (e.g., middlemen, recyclers); and the wider ecosystem comprising of government agencies. For each, we first present the value creation, capture and destruction mechanisms, summarized in Table 2.

1. The formal collection and disposal system consists of the waste collection companies owned by municipalities and private collectors with a license to collect, about half of the waste is collected at best, the rest is illegally disposed. The current collection and disposal system is based on the 'negative' value of waste: (i) customers and local authorities are willing to pay to dispose of waste, and (ii) dumpsites and landfills operate based on gateway-fees per ton or truck, not distinguishing the type of waste nor offering incentive for valorisation. Economic value is captured through monthly collection fees from households and by the budget allocation of local authorities.
2. The plastic valorisation system is profit-driven and revolves around the interaction between informal sector and recyclers. Value creation from waste starts at the informal sector, where waste pickers collect valuable plastics from (illegal) dumpsites, or go door-to-

door. Collected materials are then sold to middlemen, who resell to other middlemen, who eventually sell to recyclers. All other value creation takes place at recyclers, who add value by sorting, washing, shredding, moulding and extruding. Some recyclers capture value by selling shreds or granulates to other recyclers and exporters, others make finished goods. Currently only 3%–5% of plastics in Zambia are recycled (Montenegro Navarro et al., 2022).

3. In the wider ecosystem, the main influential factor for value creation and capture is the regulatory environment. How the regulatory environment affects the waste ecosystem will be discussed in Section 4.3. Another actor group in the wider ecosystem are NGOs. They focus on improving living conditions of waste pickers, via training and provision of protective equipment, provision of education for households on home-based waste management, or setting up buy-back centres thereby becoming part of the value chain. However, their activities are small and do not play a substantial role in the ecosystem.

To analyse how actors influence each other's value trajectories, we map the value creation or destruction mechanisms and the material flows in Figure 1. Due to mixed bin disposal, mixed collection, and dumpsite disposal, a large part of the material value of the plastics is destroyed (indicated by VD). For many plastics this is the end of life, they stay buried at dumpsites. Waste pickers collect certain types of waste from the dumpsites, thereby bringing the plastics back into the system, increasing their potential to be recycled (V_1). Plastic waste collection by waste pickers rapidly increases the material value of plastics at first, but after that, aggregation activities hardly increase the material value of the plastics (V_2 – V_4). Further material value increase requires value addition activities, such as washing, shredding and pelletizing the plastics instead of mere trading, which are all done by recyclers (V_5).

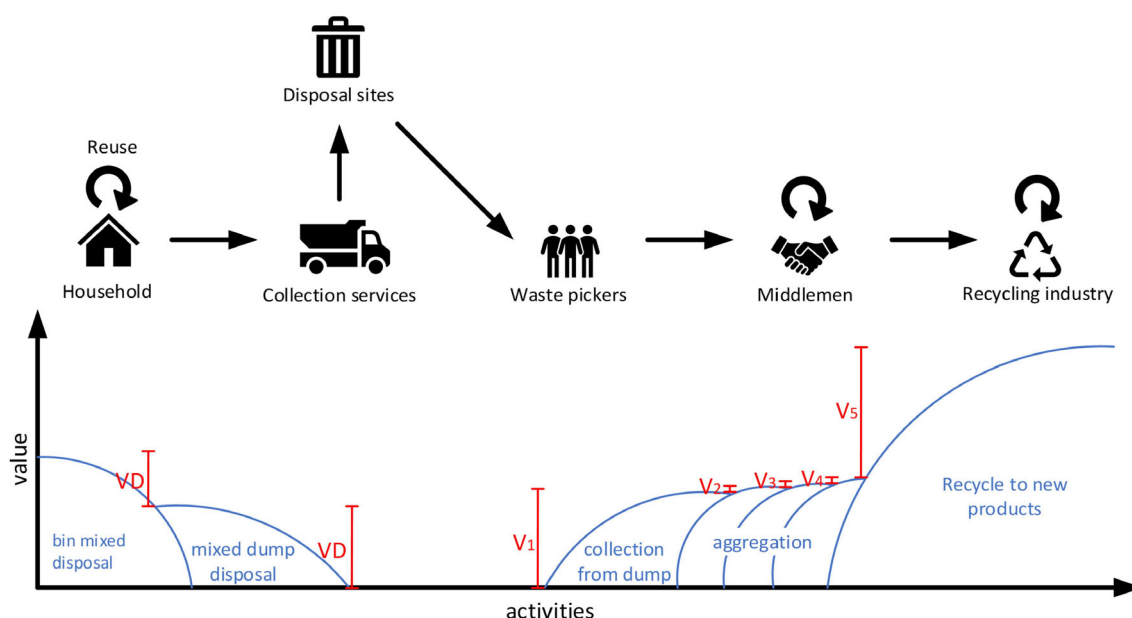


FIGURE 1 Value destruction (VD) and creation (V_1 – V_5) in the plastic waste business ecosystem in Zambia.

Thus, the value capture logic of one actor, can have a negative effect on others. For example, the value creation and capture logic of collectors is to get paid for disposing waste. This leads to contamination of plastics and mixed dumping leading to short collection windows. The business model of the collectors, negatively impact the value creation potential of waste pickers, aggregators and recyclers. The business models of the middlemen, that is, resales among each other until sufficient volumes are reached to justify a trip to the recycler, positively impacts the recycler, who has easy access to a larger quantity. However, it negatively affects the waste pickers, who can only capture little economic value, since all middlemen, with more power in the value chain need to make a profit as well. Thus, the business models of the middlemen lead to a reduction of value creation and capture potential elsewhere in the ecosystem.

The economic value capture does not align with the material value creation logic. Waste pickers create material value (V_1) by collecting certain plastics, but capture only very little economic value when selling to middlemen. Middlemen add relatively little material value (V_2 – V_4) through mere aggregation, but capture more economic value than waste pickers. This mismatch between economic value capture and material value creation may hinder growth of valorisation practices, since waste pickers are the critical actor where plastic waste valorisation starts, but with little economic incentive to do so, only the poor and desperate will collect plastics at dumps.

4.2 | Exploring actor-specific barriers to expanding waste valorisation activities

In the formal collection and disposal system, value capture for private and public collectors is challenging. Both actors report that only middle and high income households are able to pay the collection fees,

but even here the willingness or ability to pay is low, leading to small margins. Formal collection in low-income urban areas and rural areas is almost inexistent since private collectors are not able to capture economic value here, and public collectors report insufficient resources from the local authorities to cover collection costs here. This is worsened by logistical challenges in high-density low-income areas and dispersed rural areas.

In the plastic valorisation system value capture by informal sector is low, due to two issues. First, collecting plastics from dumpsites is time consuming due to mixed waste disposal at households and contamination by organics as well as the short collection window before plastics get buried by other waste. Since waste pickers get paid per kg of collected plastic, the value captured per unit of time is low, leading to low collection by the informal sector. Second, informal waste pickers sell to middlemen who sell to other middlemen handling higher volumes, until a middleman is reached who can justify the cost of transport. This leads to a system where various actors have to share the economic value captured from sales to the recycler, resulting in little profit for each. Although most value addition takes place at recyclers, recyclers still report that their economic value capture is low, preventing growth of the sector, due to issues with technology and volumes. The machinery used to recycle plastics is mainly imported from China and India, with varying quality. There are hardly any local technology providers, and equipment failure occurs regularly. When machinery breaks down, spare parts need to be imported, which is costly and time consuming. Additionally, in dry season electricity-grid blackouts occur regularly, causing severe production losses since extruders need to be reheated, taking up to 4 h. Second, gathering sufficient volumes in an economic manner is a challenge, preventing the benefits from economies of scale. Plastic materials are relatively expensive due to the time consuming manner in which plastics are currently collected by the informal sector. There is little

TABLE 3 Value creation and capture barriers in different parts of the ecosystem.

Subsystem	Value creation barriers	Value capture barriers
Formal collection and disposal system	Lack of separation at source No separated collection Low collection rate	Low ability and willingness to pay for collection
Valorisation system	Plastics at disposal sites get contaminated and buried Low plastic waste picking at dumpsites Production time loss due to machinery and equipment failure at recyclers and blackouts that hinder continuation of operation Difficult to obtain sufficient volumes	High transport costs to recyclers Low (international) prices for recyclates Low (international) prices for virgin plastics No benefits from economy of scale Small margins on recycled plastic products
Wider ecosystem		Poorly managed dumpsites Insufficient budget for (separated) collection services

recycled plastic export since the international price for recycled plastic is low, compared to the costs to collect and separate. Additionally, the international prices for virgin plastics are low, making it difficult to compete.

In the wider ecosystem, local authorities report insufficient budget for organising proper collection and disposal systems, even in the capital collection rates are 50% at best. Additionally, most people do not separate their waste, since there are no incentives to do so and there is hardly any separated collection anyways. Budget allocated to waste collection and management is chronically low due to resource constraints and competing goals.

Table 3 summarizes the barriers experienced during value creation and value capture by actors in the different subsystems.

The barriers presented in Table 3 are mapped using a simple cause-and-effect diagram, as is visualized in Figure 2. This shows that the margins made on products are low, leading to low prices for recyclates, in turn leading to low informal collection since their margins are low as a result. This leads to volumes at the recycler that are insufficient to benefit from economies of scale, reinforcing the low margins made on plastic products. Thus, it seems that there is insufficient value capture potential in the plastic valorisation system as a whole to grow: the system is trapped in a circle of low value. This low-value trap is deepened by six additional factors: (i) high cost of transport from aggregators to recyclers limit profitability for aggregators and therefore for waste pickers, leading to lower volumes at recyclers, (ii) the low formal collection rate contributes further to low volumes at the recycler, (iii) poorly managed dumpsites cause valuable plastics

to be buried before they can be picked up, leading to low plastic waste picking at the dumpsite, (iv) contamination of plastics due to lack of separation at source and collection also contributes to low plastic waste picking, (v) production time loss through blackouts and equipment failure lead to small margins on recycled products, and (vi) the low price of virgin plastics make competition fierce, driving down the price—and thus the profit margin—of recycled plastic products at the recycler.

4.3 | Analysing policy (in)effectiveness

4.3.1 | Zambia's plastics policies

On article, Zambia has adequate policies to address plastic waste valorisation. Policies are intentionally aligned to circular economy principles and recognize solid waste as a resource, promote a hierarchy of prevention, reduction, re-use, and recycling as primary considerations, followed by recovery, with disposal as the last resort (Montenegro Navarro et al., 2022). The Constitution, Acts of Parliament, and Statutory Instruments form the three types of national legislation. The Constitution is the supreme law of the Republic of Zambia. Acts of Parliament (policies) provide a framework for the priority areas set by the relevant ministries. Statutory instruments support the implementation of these policies with the aspect of enforcement. Local governments have the mandate to create by-laws to support enforcement and enhance compliance.

Two significant Acts in Zambia pertaining to waste management are the Environmental Management Act, 2011 [No. 12 of 2011] and the Solid Waste Regulation and Management Act [No. 20 of 2018]. The Environmental Management Act, 2011 serves as the overarching legislation that establishes frameworks and procedures for the conservation of the environment and the prevention of pollution. It creates the Zambia Environmental Management Agency (ZEMA), which is responsible for ensuring integrated environmental management, protecting and conserving the environment, and managing natural resources in a sustainable manner. One section of this act, Division 4, specifically focuses on waste management and covers various aspects such as the involvement of local authorities in waste management, regulations related to waste management, waste licensing, designation of waste control areas, extended producer responsibility, and the responsibilities of ZEMA. The Solid Waste Regulation and Management Act [No. 20 of 2018] is specifically designed to regulate and manage solid waste in a sustainable manner. This act encompasses provisions for both general and self-service solid waste services. It also outlines the incorporation of solid waste management companies and defines their statutory functions. The act addresses the licensing and roles of solid waste service providers, operators, and self-service solid waste providers. Additionally, it covers the regulation, operation, maintenance, and construction of landfills and other disposal facilities.

The two Acts require (i) the separation of all types of waste at point of generation, management and disposal, preventing value destruction, and (ii) mandate local authorities or licensed solid waste

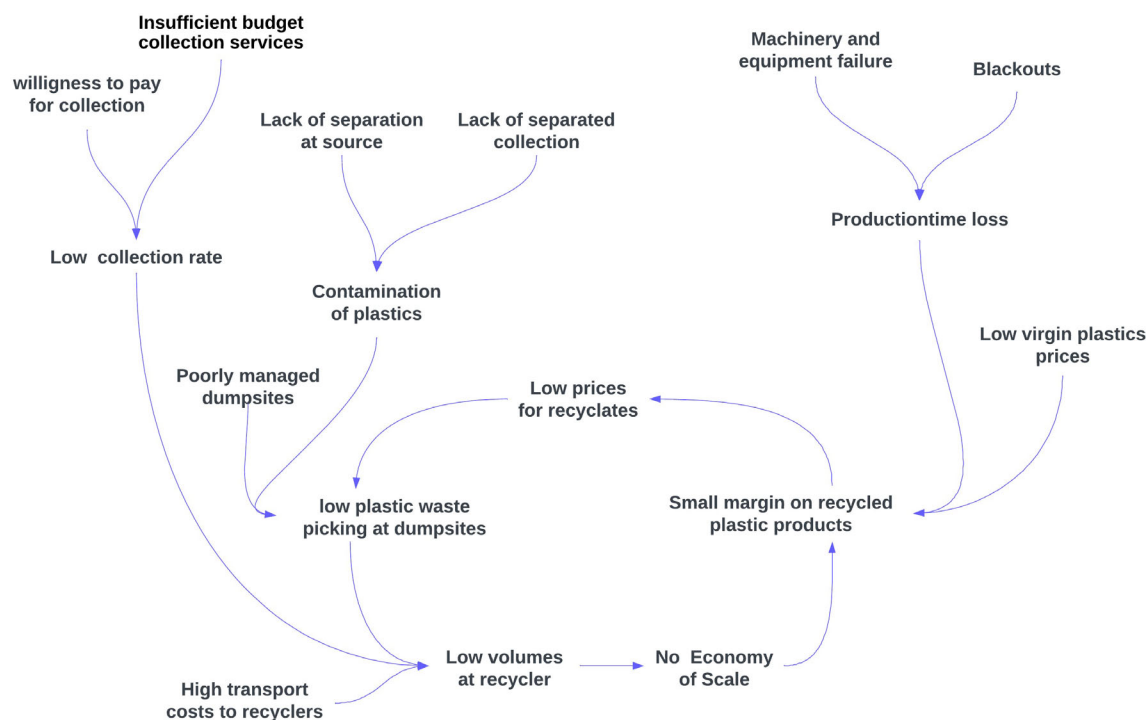


FIGURE 2 The barriers experienced by each actor during value capture and creation, leading to a low value-trap, visualised using a simple cause-and-effect diagram.

service providers to collect all household waste. In some cities such as Lusaka, households are even required by the bylaws to have waste collection services and to separate their waste. Noncompliance can be punished with high fines.

In various statutory instruments financial incentives (e.g., tax exemptions) on importation of plastic recycling and waste collection equipment are allowed, to incentivize plastic waste valorisation. Additionally, Zambia passed a statutory instrument on extended producer responsibility (EPR) regulations, which mandates the producers of plastics to be responsible for the end-of-life processing of plastics they produced or imported into Zambia. It also integrates informal waste pickers in the value chain thereby aiming to increase plastic waste collection. Finally, Zambia has recently passed a ban on single-use plastics.

4.3.2 | Effect of policies

In theory, Zambia's policies address three elements of the low-value trap directly, as can be seen in Figure 3. First, EPR regulations influence the price of recyclates, since plastics producers usually adhere to EPR regulations by financially sponsoring plastics aggregators and recyclers to buy back specific types of polymer plastics. This increased price of recyclates in turn should increase the price plastic waste pickers receive from aggregators, leading to larger amounts of plastics picked at dumpsites. Second, the ban on single use plastics might decrease the amount of plastics at the recycler, since less plastics that are of interest to recyclers, such as plastic PET bottles, are available on dumpsites. Third, the tax exemptions on imported equipment will

slightly reduce the costs of starting a waste collection or valorisation business, which might increase the emergence of such businesses.

Also in theory, Zambia's policies address two additional factors which deepen the low-value trap. First, the mandate to collect all household waste, should lead to increased willingness to pay and address the insufficient budget for collection services, leading to increased collection rates. Second, the regulation to separate waste at point of generation, management and disposal should prevent contamination of plastics and lead to a clean waste stream. Both these measures should lead to higher volumes at the recycler, since more (clean) plastics are available at dumpsites, creating benefits of economy of scale, and increasing the margins made on recycled plastic products. Increase in price for recyclates, will increase plastics collected at dumpsites, which in turn increases the volumes at the recycler, alleviating the low-value trap.

However, in practice, all regulations face serious enforcement challenges. The mandate to collect all household waste, and the requirement of waste separation are not implemented nor enforced by local authorities due to resource constraints. The awareness on the existing tax exemptions is low, both among recyclers and import authorities. The recently adopted EPR regulations and ban on single-use plastics have also not been effectively implemented.

4.3.3 | Leverage points for system improvement

Our analysis might help policy makers to make choices on where to direct their policy effort in the face of resource constraints (Singh

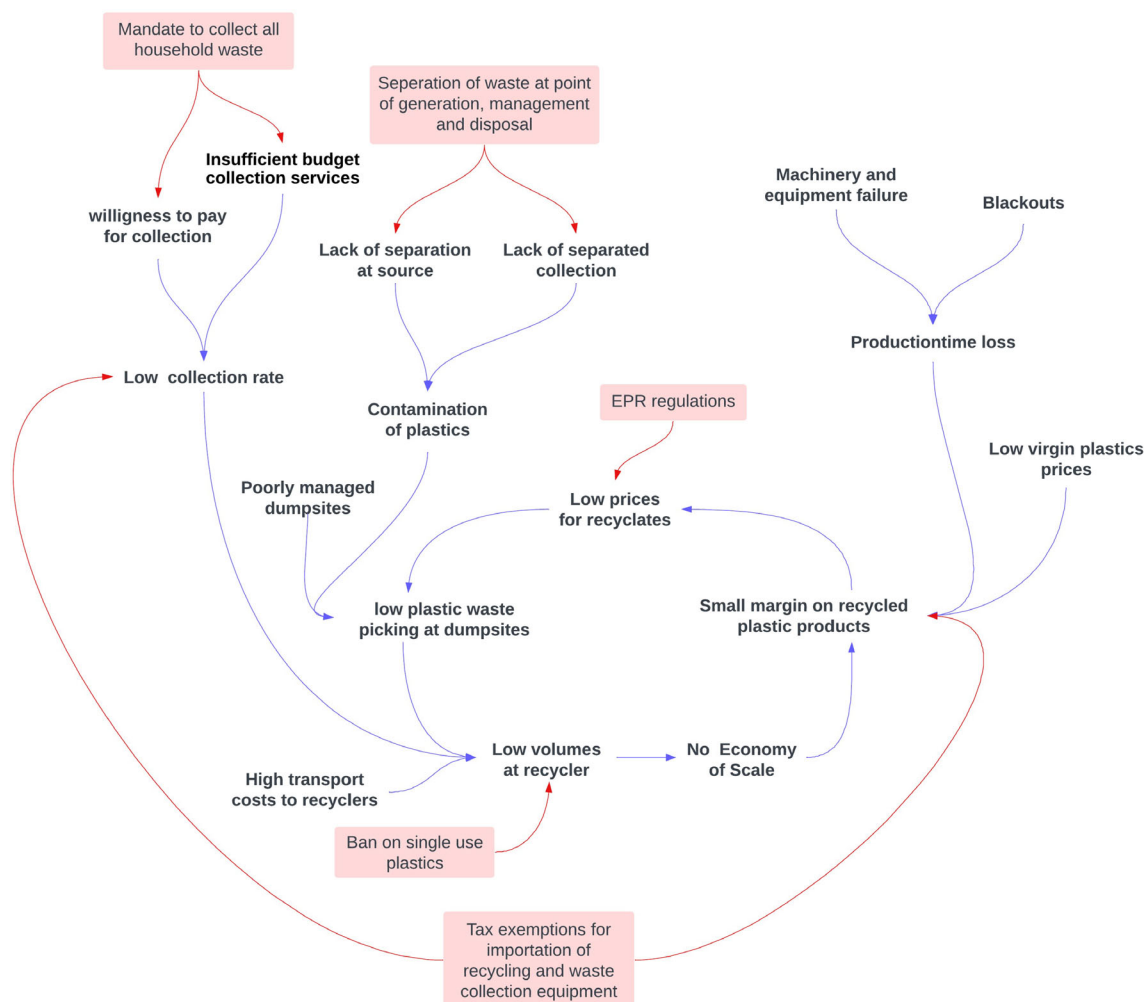


FIGURE 3 Visualisation of how policy affects the low value-trap.

et al., 2023). Based on our analysis we point out some potential directions for system improvement.

In order to increase plastic waste valorisation, the low value trap needs to be broken. There seem to be two key reasons for the existence of the low-value trap. First, there is a mismatch in value creation and capture logic in the plastic waste valorisation system, where actors that create much material value, do not always capture a fair share of economic value, resulting in lack of incentive to expand (Section 4.1). Second, all actors report difficulty in economic value capture, thus it seems there is also a lack of economic value capture potential within the valorisation system as a whole (Section 4.2).

The first key reason, mismatch in value creation and capture logic, has resulted in lack of incentive to expand plastic waste picking at dumpsites by the informal sector. The cause-and-effect diagram shows that increasing plastic waste picking, would positively affect the low-value trap. Thus, more economic value needs to trickle down to the informal sector, since these actors play an absolutely essential role which is not always recognized (Aparcana, 2017). Current policy interventions address this by mandating separation at source to prevent contamination of plastics, thus increasing their economic value,

increasing the value capture for waste pickers. However, enforcing the mandate to separate all waste, requires more than enabling policy. Households often lack the financial means to afford (separated) collection services and the bins necessary for separation. Households might also lack the space to separate and lack education and incentives to do so (Mutubuki Makuyana et al., 2022). While local authorities do not have the resources to engage in separated collection and enforce separation policies at households (Singh et al., 2023).

The second key reason, insufficient value capture potential, has resulted in low margins made by almost all actor groups, preventing growth in valorisation. Current policy interventions addressing the total amount of value capture potential in the system are: (i) the mandate to collect all household waste, which would lead to increase in the margins made on plastic products through economies of high volume handling. However, this requires significant budget allocation from governments, which is known to be challenging (Bauer, 2020). (ii) The EPR regulation which aims to increase the price of recyclates thereby increasing the value which can be captured from plastic collection. However, Zambia has not implemented its EPR regulations yet, and Johannes et al. (2021) point out that implementing an EPR

system for plastic waste in LMICs encounters numerous challenges, including high transport cost, lack of waste collection services in rural areas, a scarcity of facilities equipped to handle certain types of plastics, insufficient pollution control measures and free riding.

Therefore, Zambia might consider to redirect its efforts towards some of the other barriers that contribute to the low-value trap, which might be easier to address. There are four barriers that are not addressed by any policies as of yet. First, low virgin plastic prices result in high competition for recycled plastics, decreasing the price and therefore the profit margin. Second, high transport costs to recyclers lower the volume at the recycler. Third, poorly managed dumpsites decrease the collection window for waste pickers to collect plastics. Fourth, production time loss at recyclers lowers the margin made on plastic products. Zambia might consider policies aimed at levelling the playing field with virgin plastics such as a minimum content requirement of recycled plastics and import tax on virgin plastics. Additionally, Zambia might consider stimulating recyclers to set-up their business in close proximity to dumpsites or set-up government-sponsored buyback centres close to dumpsites to buy-back plastics from waste pickers and aggregators. Furthermore, better managed dumpsites might prevent plastics from getting buried.

5 | DISCUSSION AND CONCLUSION

This study shows that substantial plastic waste valorisation has not emerged in Zambia despite policy incentives, because the system is stuck in a low-value trap and current policy insufficiently addresses the two root causes for its existence: First, there is a disconnect between material value creation and economic value capture in the valorisation system, where actors that create much material value are unable to capture equitable economic value, discouraging key contributors from expanding. Second, all actors struggle to make an economic profit, suggesting an overall deficiency in the system's potential for value creation and capture. The low-value trap is deepened by six additional barriers: poorly managed dumpsites, low collection rate, high transport costs to recyclers, low virgin plastic prices, production time loss and contamination of plastics. Only two policies address the low value-trap directly (e.g., EPR regulations and tax exemptions), while other policies address only two out of the six additional barriers (e.g., waste collection and separation mandate). Unfortunately, all four policies face severe implementation challenges due to budget constraints.

5.1 | Implications for theory

Studies on plastic waste valorisation have tended to take either a macro policy perspective (e.g., Xie & Martin, 2022; Schröder et al., 2023; Singh et al., 2022; Deme et al., 2022), or a micro perspective zooming in on one or two specific actors (e.g., Barnes et al. 2021, Ezeah et al., 2013; Gall et al., 2020, and Godfrey et al., 2019). Our findings contribute to these two literature streams in two ways.

First, we respond to critiques of Muheirwe et al. (2022) and Bjerkli (2015) concerning macro policy studies, who observe that existing research on plastic waste policy in LMICs often entails ambitious policy agendas, while simultaneously highlighting the limited implementation capabilities of local authorities for executing such an agenda. These studies generally start by observing current policies and often compare this to policies in western countries (Muheirwe et al., 2022). We show that it is essential to start the study of policy with a deep understanding of the actors that will need to change or grow for effective plastic waste valorisation to happen, and how they are interconnected. Mapping their value creation and capture trajectories, followed by assessing how this influences the functioning of the system, and then analysing how existing policies influence this system, can help to prioritise which key barriers to address with policy in face of resource constraints. It helps to see how policies affect waste actors and their interactions. Our findings can help to make macro policy studies more realistic. Instead of proposing large lists of measures and interventions, such as Xie and Martin (2022), and Schröder et al. (2023), macro studies could use this way of analysing to establish priorities, by testing whether or how each policy influences the core reasons for limited growth of the plastic waste valorisation system.

Second, micro studies offer mainly individual business model solutions, without considering broader implications. Such partial “solutions” might be inadequate to set off systemic change, or they could even misfire as they might lead individual actors to pursue mutually inconsistent business model innovation strategies. Our work constitutes a significant step towards overcoming these limitations through adopting a holistic ecosystem perspective when studying waste actors in LMICs. We show that analysing the value creation and capture trajectories of individual actors influences, and is affected by, the potential of the whole system to create and capture value, and that policies need to address issues of intra-system coordination. Future micro studies could use this way of analysis to assess how changes either in policy or another actor's business model, that might seem far from their actor of study, can still affect them.

Additionally, we build upon Peltola et al. (2016) and Leder et al. (2020), who focus on inter-stakeholder relations and analyse value creation and capture practices within circular ecosystems. Although valuable in itself to understand how a system as a whole is (un)able to create circular value, they have not provided guidance on system improvement, with their statements being mere observations. We show that an ecosystem analysis can be a great starting point for effective policy analysis, and broaden the relevance of using an ecosystem perspective, beyond business scholars, towards policy scholars. In this way our findings provide support for the added analytical value of combining an ecosystem analysis with a policy analysis to design more effective interventions in situations of resource constraints.

5.2 | Implications for practice

An expanded understanding of why plastic waste valorisation has not emerged as expected in LMICs, despite policy interventions, and

practical guidance on *how* to address this, can empower policy makers, practitioners and entrepreneurs to create transformative change.

Although some of the challenges towards plastic waste valorisation have been identified in prior literature (e.g., limited informal sector integration by Akinboade et al. (2012), local authority's resource constraints by Bauer (2020), challenges in aggregators' business models Barnes et al. (2021), our study is able to identify how individual actor's barriers interact and create a low-value trap for the system actors collectively, distinguishing cause and effect, and showing the (limited) effect of existing policy has on this trap. Our study underlines the crucial function of governmental actors as regulators and business enablers in the plastic waste valorisation system. Up until now, most waste related policies are aimed at improving the collection infrastructure. Our study shows that policies focused on improving the waste infrastructure, which has proven to be ineffective due to severe budget constraints for public waste management, is not the only intervention regulators can use to improve the waste system without investing significant funds. As we showed, focusing on regulations to stimulate valorisation of plastic waste, such as levelling the playing field with virgin plastics, could be another avenue to work towards the breakdown of the low-value trap. Furthermore, there is a lot of potential for shared value creation between formal and informal sector, which calls for stimulation of better collaboration between these. Finally, the study provides entrepreneurs with the opportunity to think through the effect of possible business model innovations, before implementation. For example, from our analysis one can conclude that setting up a WTS alone might not be a profitable undertaking since a WTS will still be hindered by the low profit margin received from recyclers. However, if the WTS executes more value addition activities such as washing and shredding, creating more value from their materials, this might allow it to capture more economic value when selling to recyclers. In these ways our analysis provides realistic and operationalizable guidance for various actors on how to improve plastic waste valorisation.

5.3 | Limitations and future research directions

Although this study has been meticulously conducted, it has a few limitations. For instance, our case focused on urban areas of Zambia, so the results should not be generalized to the entire country. For rural areas the analysis could yield different answers because of the large difference in waste composition and the lack of both formal and informal waste management infrastructure. Additionally, although the single case study's results provide insights for other LMICs, since their waste management structure is often quite similar (Ezeah et al., 2013; Ayeleru et al., 2020), it should not be generalized completely. Every country and every area might have their specific dynamics that need to be taken into account. However, our work does provide a good starting point for similar analyses in other LMICs. Furthermore, our methodological approach holds potential for wider applicability. It provides a means towards operationalising an ecosystem perspective to conduct more effective policy analysis

paving the way for prioritisation and sequencing. But it does not by itself provide a full policy analysis on which policies to prioritise and why. Additionally, it does not thoroughly analyse the reasons for ineffective implementation of existing policies, beyond highlighting resource and capacity constraints. Future research could focus on testing the ability of specific policy interventions to address barriers identified as causing the low-value trap, as well as exact dynamics for ineffective policy implementation. However, one should note that it is eventually up to governments to decide which policy direction to take. More studies like these could help them make informed decisions.

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ENDNOTE

¹ Note that manufacturers of plastics that use both virgin and recycled plastics, are included in the group 'recyclers'.

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