



## REVIEW ARTICLE

### Scaling Waste-to-Wealth Ventures in Emerging Markets: A Circular Economy Framework for Sustainable Growth

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#### Abstract

The circular economy offers emerging markets a growth path that is less dependent on continued resource extraction, and waste-to-wealth ventures have multiplied in response. Few, however, achieve scale. This article asks what distinguishes ventures that replicate across markets from those that remain confined to a single site, and develops a conceptual framework to answer that question. A structured conceptual review was conducted across four bodies of literature: circular economy theory, waste management in developing economies, the informal recycling sector, and the relationship between circular practice and development objectives. The review redefines scale as replication, meaning the capacity to operate the same model in further contexts without loss of unit economics or environmental performance, rather than as private-market valuation. The resulting framework identifies three enablers of scale, namely an adaptive business model, a hybrid capital structure and policy co-creation, and argues that they act through a mediating capability, ecosystem orchestration, which aligns informal collectors, offtakers, municipalities and financiers around a single material flow. Scaling is specified as four stages in which the binding constraint shifts from technical proof to feedstock security, then to offtake and finally to policy stability, so that support instruments must be matched to stage. The framework contributes four falsifiable propositions and a set of indicators observable without proprietary disclosure, and it treats the integration of informal collectors as the mechanism of feedstock security rather than as a social obligation. The South African case, where extended producer responsibility regulations and a national waste picker integration guideline now formalise relationships that were previously voluntary, illustrates the policy relevance of the framework. The framework is presented for empirical testing, and a validation pathway combining expert consultation, comparative case studies and configurational analysis is proposed.

**Keywords:** circular economy, ecosystem orchestration, emerging markets, informal recycling sector, South Africa, venture scaling, waste valorisation

#### Introduction

The linear model of production and consumption, in which materials are extracted, converted into products and discarded after a single use, is increasingly difficult to defend on environmental or economic grounds. The circular economy proposes an alternative in which value is retained through reuse, remanufacturing and recycling, and in which waste is treated as a misplaced input rather than an endpoint [1,2]. The concept has attracted rapid academic and policy attention, yet its boundaries remain contested. An analysis of 114 definitions found that most reduce the concept to a combination of reduce, reuse and recycle activities while neglecting the systemic change that circularity requires [3], and a later analysis of 221 definitions found that the social dimension and the question of systemic change remain under-

represented [4]. Geissdoerfer and colleagues [2] further showed that the circular economy and sustainability are related but not equivalent, and that conflating them obscures what each demands. These definitional debates matter for the present study because a framework for scaling circular ventures must specify which outcomes count as circular success before it can explain how that success is reproduced.

Most of this literature has been written from, and about, industrialised economies. Reviews of the field indicate that the expected transition has been theorised largely in European and Chinese policy settings [1], and that the barriers identified there, chiefly cultural and market barriers rather than technological ones, may not transfer to other institutional environments [5,6]. Halog and Anieke [7] similarly caution that circular economy approaches developed in high-income countries cannot simply be adopted in developing countries without attention to institutional and infrastructural differences. Emerging markets present a configuration that differs in kind rather than in degree: waste collection coverage is incomplete, disposal infrastructure is limited, and a large informal recycling sector already performs much of the material recovery that formal systems perform elsewhere [8–11].

That configuration is simultaneously a constraint and an opportunity, depending on what a venture is able to organise. It is a constraint because feedstock supply is fragmented, quality is variable, and municipal systems are often unable to guarantee either [11,12]. It is an opportunity because material is available at low cost, labour is abundant, and the absence of legacy infrastructure permits business models that would face incumbent resistance in mature markets [13]. Against this background, a class of ventures has emerged that converts waste streams into commercial products. A small number have attained the private-market valuations associated with the term unicorn, while a far larger number have not, despite comparable technology and comparable environmental promise. This article asks why: what distinguishes ventures that replicate across markets from those that remain confined to a single city or contract? The question matters beyond the ventures themselves, because circular practices bear directly on several Sustainable Development Goal (SDG) targets, with the strongest relationships identified for clean water and sanitation, affordable and clean energy, decent work and economic growth, responsible consumption and production, and life on land [14,15].

The study responds to three interrelated gaps. The first is geographic. The evidence base for circular business models is drawn predominantly from contexts whose institutional and infrastructural conditions differ from those in which most waste-to-wealth ventures operate [1,7,13]. The second is analytical. Scaling is usually described through case narratives rather than specified as a process with identifiable stages and constraints. Bocken and colleagues [16], for example, identified four scaling strategies among social businesses in developing markets and observed that each becomes important at a different stage of maturity, but they left the sequencing of those strategies as an open question. Work on circular ecosystems has proposed principles of collaboration and platform building [17], and barrier studies have catalogued obstacles across several domains [18], yet neither literature explains which constraint binds at which point in a venture's development. The third gap is integrative. Sustainability performance and investment appraisal are treated in separate literatures, with circularity indicators measuring material outcomes [19,20] and venture appraisal measuring financial ones, and little connects the two [21].

The framework developed in this article addresses these gaps together, and its contribution is fourfold. Theoretically, it redefines scale in operational rather than financial terms and specifies ecosystem orchestration as the mediating capability through which three enablers (an adaptive business model, a hybrid capital structure and policy co-creation) affect replication. In doing so, it reframes the integration of informal collectors as the mechanism through which feedstock security is achieved rather than as a social obligation appended to the business model [22–24]. Methodologically, it converts a literature of case narratives into four falsifiable propositions and a set of indicators that can be observed from documents ventures already

produce, which responds to calls for conceptual work that yields testable models [25,26]. Practically, it offers entrepreneurs, investors and development finance institutions a stage-contingent view of which constraint to address first. For policy, it shows why instrument stability and municipal implementation matter more than instrument generosity, and it examines these implications in the South African context, where extended producer responsibility (EPR) regulations and a national waste picker integration guideline have recently formalised relationships that were previously voluntary [27,28]. The framework is offered as a structure for empirical testing rather than as a validated model, and the article distinguishes throughout between claims that rest on published evidence and propositions that await it.

A note on terminology clarifies how this study departs from popular usage. The venture literature uses the term unicorn to denote privately held companies valued above one billion United States dollars [29], and the sustainability literature has begun to borrow it. The term is analytically weak for present purposes for three reasons. It classifies ventures by a valuation set in private markets rather than by any operating property, so it measures investor expectation as much as performance. It is denominated in dollars, which makes it insensitive to the scale of the problem a venture addresses in its own market; a venture that diverts a material share of a mid-sized city's waste may never approach the threshold, whereas a platform intermediary with modest environmental effect may exceed it. It is also a stock measure applied to what is fundamentally a process question. Scale is therefore defined here as replication: the capacity to operate the same model in a second and third context without loss of unit economics or environmental performance. This definition is operational, applies equally to ventures in small and large markets, and is observable from what a venture does rather than from what investors believe it is worth. The distinction is consequential, because the conditions that produce a high valuation and those that produce replication are not the same, and conflating them partly explains why the existing literature accounts for scaling poorly [16,21].

The remainder of the article is organised as follows. Section 2 describes the review design and the literature search and selection process. Section 3 characterises the operating context and business models of emerging-market circular ventures, synthesises the barriers to scale, presents the framework, its stages, indicators and propositions, and examines its implications for development outcomes, for South African policy and for future validation. The final section concludes.

## **Research Methodology**

### ***Review design***

The study is a structured conceptual review rather than an empirical investigation; it therefore reports no primary data and undertakes no statistical analysis. It follows the integrative review tradition, in which literature from different fields is synthesised to generate a new conceptual framework rather than to estimate an effect size [30,31]. Within Jaakkola's [25] typology of conceptual articles, it is a model paper: it identifies constructs, specifies the relationships among them and states propositions that can subsequently be tested. A semi-structured rather than fully systematic protocol was chosen because the relevant evidence is dispersed across management, environmental science, development studies and policy literatures that use different vocabularies, which makes a single exhaustive search string impractical [31]. The design decisions reported below concern how the evidence base was assembled, how the framework was derived from it, and how the limits of each claim were established, since a conceptual contribution stands or falls on those decisions [25,32].

### ***Literature search and selection***

The search covered four bodies of literature: (i) conceptual work defining the circular economy and distinguishing it from sustainability; (ii) empirical work on waste management and recycling in developing economies, including the informal sector; (iii) studies relating

circular practices to the SDGs; and (iv) research on circular business models, their financing and their barriers. Searches were run in Scopus, Web of Science and Google Scholar, supplemented by ResearchGate and by Elicit, an AI-assisted literature search tool, to capture relevant work not indexed in the bibliographic databases. The search and selection protocol is summarised in Table 1. Peer-reviewed journal articles were preferred throughout, and sources reporting original evidence or original conceptual analysis were preferred over secondary syntheses. Institutional and official sources were admitted where they supply data or regulatory content unavailable in the peer-reviewed literature, principally global waste statistics [8] and South African legislation and policy [27,28,33,34].

Table 1. Literature search and selection protocol

| Element                               | Specification                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bodies of literature                  | (i) Circular economy concepts and definitions; (ii) waste management and recycling in developing economies, including the informal sector; (iii) circular economy and the SDGs; (iv) circular business models, finance and barriers                                                                                                                                                                                                                                     |
| Search sources                        | Scopus, Web of Science and Google Scholar; supplemented by ResearchGate and Elicit (AI-assisted literature search)                                                                                                                                                                                                                                                                                                                                                      |
| Publication years of retained sources | 2006–2023 for substantive sources; seminal methodological works from 1989                                                                                                                                                                                                                                                                                                                                                                                               |
| Core search terms                     | Combined with Boolean operators and adapted to each source: "circular economy" AND (definition* OR concept*); ("waste management" OR recycling) AND ("developing countr*" OR "emerging market*" OR "global South"); ("informal sector" OR "waste picker*" OR reclaimer*) AND ("circular economy" OR recycling); "circular economy" AND ("Sustainable Development Goals" OR SDG*); ("circular business model*" OR "circular economy") AND (barrier* OR financ* OR scal*) |
| Language and document types           | English; peer-reviewed articles (preferred), scholarly books and chapters, and official legislation, policy and institutional reports where they supply data unavailable elsewhere                                                                                                                                                                                                                                                                                      |
| Inclusion criteria                    | Original evidence or conceptual analysis on at least one of four questions: definition and boundaries of circularity; conditions specific to emerging markets; barriers to scaling; relation of circular outcomes to development objectives                                                                                                                                                                                                                             |
| Exclusion criteria                    | Commentary without supporting evidence; quantitative claims without a recoverable method or sample; industry and investor material without a stated method                                                                                                                                                                                                                                                                                                              |
| Screening                             | Two stages: titles and abstracts, then full texts                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Records identified                    | 2,300                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Final corpus                          | 50 substantive sources (plus 9 methodological references)                                                                                                                                                                                                                                                                                                                                                                                                               |
| Analysis                              | Abductive synthesis into constructs, mechanisms, indicators and propositions                                                                                                                                                                                                                                                                                                                                                                                            |

*SDGs: Sustainable Development Goals. AI: artificial intelligence.*

Sources were included when they reported original evidence or conceptual analysis bearing on at least one of four questions: how circularity is defined and bounded; which conditions distinguish circular practice in emerging markets from practice elsewhere; which barriers ventures encounter when scaling; and how circular outcomes relate to development objectives. Commentary without supporting evidence was excluded, as were sources reporting quantitative claims without a recoverable method or sample. The searches identified 2,300 records. These were screened in two stages, first on titles and abstracts and then on full texts, against the criteria above. The final analytical corpus comprised the 50 substantive sources cited in this

article; a further nine methodological references inform the review design and the proposed validation pathway. Because Elicit and Google Scholar rank results by relevance rather than returning a fixed set, the 2,300 records should be read as the volume screened rather than as an exhaustively reproducible population [31].

### ***Framework derivation and treatment of evidence***

The framework was derived abductively. The enablers were specified as the smallest set of conditions that accounts for the differences the empirical literature records between ventures that replicate and ventures that do not, and each enabler was stated so that it implies an observable condition [25,26]. This specification is what makes the framework testable, and Table 3 states the indicator through which each component would be observed. Following Corley and Gioia [32], the contribution is judged on both originality and practical utility, so each component was retained only if it either altered how scaling is explained or altered what a practitioner or policymaker would do. No claim is made that the framework has been tested, and the propositions in Section 3.6 are advanced as hypotheses.

One methodological caution governs the whole article and explains several of its omissions. The waste-to-wealth sector generates a large volume of quantitative material in industry reports, investor communications and venture databases, much of which cannot be traced to a stated method or sample. Figures of that kind are not reproduced here. Where the article states a magnitude, it is attributable to a cited source; where it describes a pattern without a magnitude, the pattern is qualitative in the underlying evidence and is presented as such [19,31].

## **Results and Discussion**

### ***The operating context of emerging-market circular ventures***

Three features of the emerging-market context shape what a circular venture can and cannot do. The first is the scale and trajectory of waste generation. Global assessments project municipal solid waste to rise from about 2.01 billion tonnes in 2016 to about 3.40 billion tonnes in 2050, with the steepest increases in lower-income regions where collection coverage is already lowest [8]; mismanagement in those regions, including open dumping and burning, imposes substantial environmental and public-health costs [11]. The second feature is the centrality of the informal sector. Informal collectors perform a large share of material recovery in cities across the global South, often at little cost to municipalities [9], and their organisations demonstrably contribute to circular outcomes [10,22,35]. The third is the unevenness of regulatory capacity. National histories of waste management, such as South Africa's, show that policy ambition has often exceeded implementation capability [36], and comparative assessments across Africa characterise the waste crisis as partly a governance failure [37,38].

These features interact in ways that are poorly captured when emerging markets are treated as less developed versions of mature ones. A venture entering such a market does not encounter an absence of circular activity. Instead, it encounters an existing, low-margin, labour-intensive circularity operated by people with no formal claim on the value they create [9,35]. The strategic question is therefore whether the venture displaces that activity, competes with it or organises it. The evidence on integration suggests that organisation is both more workable and more defensible: Gutberlet and colleagues [22] document the services that waste picker organisations already provide in Argentina and Brazil, Gall and colleagues [24] show that plastics collected by waste pickers can reach high recycle quality within a hybrid business model, and Velis and colleagues [23] argue that enabling rather than superseding the informal sector is a precondition for an inclusive circular economy. This evidence base is, however, dominated by Latin American cases, and it remains an open question how far the findings transfer to contexts where collector organisation is weaker.

Comparable dynamics appear across other developing economies, which supports treating the pattern as general rather than local. Case evidence from Nigeria documents the application of circular principles to industrial solid waste under similar infrastructural constraints [39]; analysis of the Sri Lankan recycling industry identifies recurring challenges in feedstock quality, market access and financing [12]; and an assessment of governance capacity in Kenya shows that public-sector leadership and convening power condition whether resource recovery from urban waste can be implemented [38]. The consistency of these constraints across geographies justifies treating emerging-market circular ventures as an analytical category rather than a collection of national special cases, while the differences in institutional capacity among them caution against assuming that a single prescription applies uniformly [7].

### ***Business models in waste valorisation***

Waste-to-wealth ventures are not a single business model but a family of models, and the differences bear directly on what scaling requires. Conceptual work on circular business models distinguishes configurations by where value is created in the resource loop, covering the value proposition, the structure of the value chain and the revenue mechanism [40]. Bocken and colleagues [41] distinguish strategies that slow, close or narrow resource loops, while Geissdoerfer and colleagues [42] link business model choices to supply chain configurations. Applied to waste valorisation in emerging markets, these typologies suggest four recurring configurations.

Material processors convert collected waste into a substitute input, such as recycled polymer, compost or construction material. Their economics depend on feedstock cost and on the price spread against the virgin material they displace, which exposes them to commodity cycles and to feedstock quality in equal measure [12,24]. Energy recovery ventures convert organic or mixed waste into fuel, heat or electricity, and their economics depend heavily on the available tariff or offtake arrangement, which is typically a regulated rather than a market variable [38,39]. Platform intermediaries do not process material but match supply and demand across a fragmented collection base; this lowers capital intensity but increases dependence on network density [17]. Product ventures embed recovered material in a branded consumer or industrial product, capturing more of the value chain but carrying correspondingly greater commercial risk, including the customer acceptance and product return uncertainties that Linder and Williander [43] identify as inherent to circular business model innovation.

These configurations face different binding constraints, which is why a single scaling prescription fails. A processor is constrained by feedstock security and by the spread against virgin material; a platform by liquidity on both sides of its market; an energy venture by the durability of its tariff arrangement; and a product venture by consumer or industrial acceptance of recycled specification [18,43]. The framework developed below applies across all four, but the weight of each enabler differs by configuration, and empirical tests would need to stratify ventures accordingly rather than pooling them.

What the four configurations share is dependence on an upstream collection system that the venture does not control. This feature distinguishes waste valorisation from most manufacturing, where inputs are purchased on established markets at known specifications. In waste valorisation, the input is produced as a by-product of consumption, gathered by actors outside any contract and delivered in variable condition [9,12]. Circular practice in this setting is therefore as much an exercise in supply organisation as in processing technology, a point that the technology-focused literature tends to understate [15,42].

### ***Barriers to scale***

The barriers that ventures encounter can be grouped into six domains, which are set out in Table 2 with the evidence that documents each. The grouping draws on, but is narrower than,

general barrier frameworks for circular business [6,18], because it is restricted to barriers documented in emerging-market settings.

Table 2. Barriers to scaling waste-to-wealth ventures in emerging markets

| Domain         | Barrier                                                                                 | Supporting evidence |
|----------------|-----------------------------------------------------------------------------------------|---------------------|
| Feedstock      | Fragmented, variable-quality material supply dependent on informal collection           | [8–10]              |
| Finance        | Limited patient capital; appraisal models that do not price circular assets or risks    | [5,21,44]           |
| Infrastructure | Incomplete collection, sorting and logistics systems                                    | [8,11,12]           |
| Policy         | Ambition exceeding implementation capacity; instability of incentives                   | [36,38,39]          |
| Market         | Thin and volatile secondary-material markets; weak offtake demand                       | [1,12,43]           |
| Social         | Risk of displacing informal livelihoods, with reputational and operational consequences | [22,23,45]          |

*Domains are the authors' grouping. The evidence column cites sources that document each barrier; they do not quantify its magnitude.*

Two observations follow from the grouping, and both bear on how interventions should be designed. First, the barriers are predominantly institutional and market-related rather than technological. This mirrors the European finding that cultural and market barriers dominate technological ones [5] and the cross-regional finding that institutional factors help explain why recycling dominates over reuse and reduction [6], and it suggests that technology transfer alone will not resolve them. Second, the barriers are interdependent. Feedstock insecurity raises the cost of capital, a higher cost of capital shortens the horizon over which offtake contracts can be negotiated, and a short contracting horizon weakens the venture's position in policy engagement [21,43,44]. This interdependence is the reason a framework is needed: a barrier list implies that each obstacle can be removed independently, whereas the evidence suggests that their removal must be sequenced.

### *A framework for scaling*

Figure 1 presents the proposed framework, in which three enablers act on a venture's capacity to replicate, each addressing one or more of the constraints identified in Table 2. An adaptive business model is one whose unit economics survive relocation, which in practice means modular processing capacity and a product specification that tolerates feedstock variation [41,43]. A hybrid capital structure combines concessional, impact and commercial tranches so that the risks the market will not price, principally feedstock and policy risk, are borne by capital willing to accept them [21,44]; it mirrors, on the financing side, the hybrid organising of social and commercial logics that characterises social enterprises [46]. Policy co-creation is sustained engagement with regulators and municipalities, directed at the conditions that determine feedstock access and offtake demand rather than at subsidy alone, and it draws on the collaborative governance literature, which identifies trust-building, shared commitment and intermediate outcomes as conditions of effective public–private collaboration [47,48].

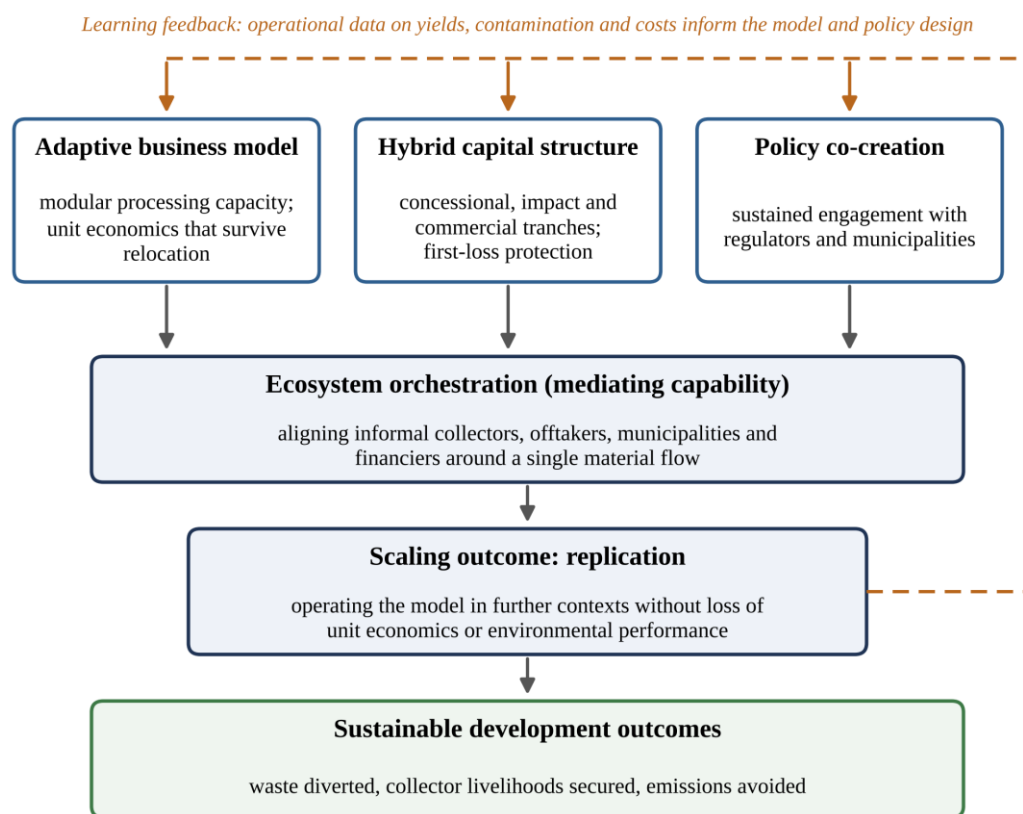


Figure 1. Conceptual framework for scaling waste-to-wealth ventures in emerging markets  
The framework is the authors' construction and has not been empirically tested. Components and indicators are specified in Table 3.

The central claim of the framework is that these enablers do not act independently but through ecosystem orchestration, defined as the alignment of informal collectors, offtakers, municipalities and financiers around a single material flow. The construct builds on Adner's [49] structural view of ecosystems as the alignment of partners required for a value proposition to materialise, and on Dhanaraj and Parkhe's [50] account of how hub firms orchestrate networks by managing knowledge mobility, appropriability and stability. Konietzko and colleagues [17] extend ecosystem thinking to circular innovation, but their principles were derived largely from firms in industrialised economies and do not address actors who operate outside formal contracts. This is where the present framework departs from accounts that treat scaling as a function of technology or capital. A venture with excellent technology and ample capital that has not secured feedstock from the people who actually collect it, or demand from buyers who will accept recycled specification, has not solved the problem that constrains it. Integration of informal collectors is therefore not a social obligation appended to the business model but the mechanism through which feedstock security is achieved [22–24].

The feedback path shown in Figure 1 completes the framework and distinguishes it from a linear account. Ventures that reach scale acquire operational data on collection yields, contamination rates and processing costs that no external party holds. These data improve the venture's own model and, where shared with regulators, the design of policy instruments [47,48]. This is the mechanism through which policy co-creation becomes credible rather than rhetorical, since a venture that can demonstrate diversion volumes offers a municipality evidence for planning rather than only a request for support [37,38].

Scaling stages and binding constraints

Scaling is not a single transition but a sequence in which the binding constraint changes, and conflating the stages is a common source of misdirected intervention. Figure 2 sets out four stages, with the binding constraint, the appropriate capital type and the impact evidence associated with each. This stage model responds directly to the sequencing question left open by Bocken and colleagues [16], but it orders stages by the constraint that binds rather than by the growth strategy pursued. At validation, the constraint is technical, and grant or concessional capital is appropriate because no commercial return is yet demonstrable. At consolidation, the constraint shifts to feedstock security, which is an organisational rather than a technical problem [9,24]. At replication, it shifts to offtake, since a second site cannot be justified without demand for its output [43]. At regional scale, the constraint is policy stability, because cross-border replication exposes the venture to several regulatory regimes at once [6,48].

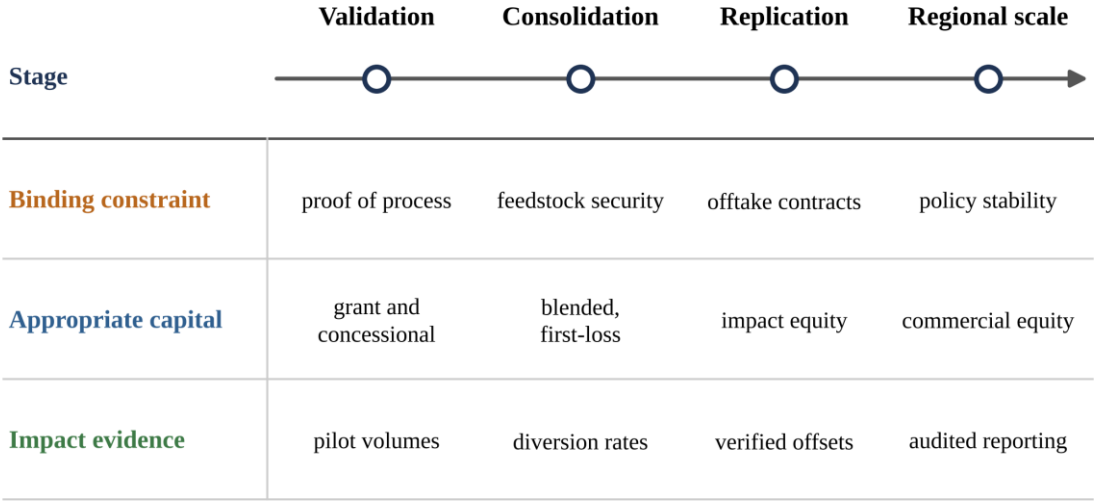


Figure 2. Scaling stages, binding constraints, appropriate capital and impact evidence  
*The stages are the authors' construction. The progression is analytical rather than empirical, and no timing is implied.*

The practical implication is that support instruments should be matched to the stage a venture has reached rather than offered on a standard schedule. Concessional capital offered at the replication stage addresses a constraint that has already been resolved, while technical assistance offered at regional scale addresses a problem the venture has already solved more than once [21,44]. Such mismatches may partly explain the gap between the volume of development finance directed at circular ventures and the number that achieve scale, although this proposition is untested and is offered as such.

Two features of the stage model run counter to how scaling is usually depicted. First, progression through the stages is not monotonic. A venture that has secured feedstock in one city and moves to a second does not carry that security with it, because collection arrangements are local and the relationships underpinning them are personal as much as contractual [22,35]. Replication therefore returns the venture to a constraint it has already resolved once, which is why the capability that matters is the ability to rebuild such arrangements quickly rather than any particular arrangement. In this sense, orchestration is a capability rather than an asset [49,50]. Second, the stages impose different organisational demands, and the skills that carry a venture through one stage may impede the next. Validation rewards technical problem-solving and improvisation; consolidation rewards patient negotiation with parties who may have reason to distrust formal enterprises; replication rewards standardisation and documentation, which an

improvisational culture tends to resist; and regional scale rewards political and regulatory fluency across jurisdictions [16,43,46]. Founder capability is therefore better understood as a stage-specific requirement than as a fixed endowment that predicts success.

### **Framework components, indicators and propositions**

Table 3 states each component of the framework, the mechanism through which it acts and the indicator through which it would be observed. Specifying indicators is what distinguishes a testable framework from a descriptive one [25,26], and each indicator was chosen to be observable from documents that ventures, funders or municipalities already produce rather than requiring proprietary disclosure.

Table 3. Framework components, mechanisms and observable indicators

| <b>Component</b>         | <b>Mechanism</b>                                                               | <b>Observable indicator</b>                                                                                                    |
|--------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Adaptive business model  | Unit economics survive relocation to a new feedstock context                   | Ratio of site-specific to transferable capital cost; tolerance of product specification to feedstock variation                 |
| Hybrid capital structure | Unpriced risk is absorbed by capital willing to bear it                        | Share of concessional or first-loss capital in the structure at each funding round                                             |
| Policy co-creation       | Regulatory conditions for feedstock and offtake are shaped rather than awaited | Documented participation in regulatory consultation; contracts with municipalities                                             |
| Ecosystem orchestration  | Collectors, offtakers and municipalities are aligned to one material flow      | Proportion of feedstock under contract; number of formalised collector relationships; documented terms of collector engagement |
| Learning feedback        | Operational data improve both the model and policy design                      | Existence and use of diversion and contamination measurement; data shared with regulators                                      |

*Indicators are proposed by the authors and have not been validated. They are intended to be observable without proprietary disclosure.*

The framework yields four propositions, each stated so that it can be rejected rather than merely illustrated.

**P1.** Ventures whose feedstock is secured through contracted relationships with organised collectors replicate more readily than ventures relying on spot purchase, because feedstock security is the binding constraint at the consolidation stage.

**P2.** The presence of concessional or first-loss capital in the capital structure predicts progression to replication more strongly than the total capital raised, because the function of such capital is to absorb unpriced risk rather than to fund operations.

**P3.** Documented regulatory engagement predicts survival through policy transitions, because ventures that helped to shape an instrument are better placed when it is revised.

**P4.** Ventures that displace rather than integrate informal collectors experience higher feedstock volatility; this is the testable form of the claim that integration is a business necessity rather than a social courtesy.

### **Development outcomes and the measurement problem**

The development case for waste-to-wealth ventures is often asserted in general terms, but the literature permits a more precise and more cautious assessment. A systematic matching of circular practices to SDG targets found strong synergies with Goals 6, 7, 8, 12 and 15, but also identified trade-offs between recycling practices and targets for safe working environments and

human health [14]. This finding contradicts the assumption that circular scaling and development outcomes move together automatically. In the waste-to-wealth context, the trade-off is concrete and arises where the business model is most profitable: scaling a processing operation can improve material recovery while worsening conditions for the collectors who supply it, if the venture's cost advantage derives from paying less than the value of the material it receives. The occupational hazards documented for informal collectors make this a matter of health as well as income [11,23,51]. A venture that reports against SDG 12 while worsening conditions relevant to SDG 8 has therefore not made the case its reporting implies.

Measurement compounds the difficulty. A venture's environmental performance is part of its investment case, and frequently the part that attracts concessional or impact capital, yet the available indicators are inconsistent. Reviews of circularity indicators find that they measure materially different things, ranging from material retention to product lifetime and recycling rates, and that they are not interchangeable [19,52]; Corona and colleagues [20] conclude that no existing metric captures circularity fully. An investor comparing two ventures on reported circularity may therefore be comparing quantities with different referents. The resulting error is systematic rather than random. Indicators that are cheap to compute, such as tonnes collected or diversion percentages, are reported more often than indicators that require life-cycle information, and ventures accordingly optimise for the former. A venture collecting large volumes of low-value mixed material may report favourably while achieving less environmental benefit than one processing smaller volumes of a difficult stream. Because concessional capital is allocated partly on such figures, the measurement problem propagates into the capital structure and therefore into which ventures scale [20,21].

Two responses are available without waiting for indicator practice to converge. Appraisal can rest on auditable material-flow evidence, meaning tonnages by stream with independently verifiable destinations, rather than on composite scores whose construction is opaque [19,52]. Appraisal can also examine the terms on which feedstock is obtained, since a venture whose margin derives from underpaying collectors has an environmental case that is not matched by a social one [14,22,23]. The indicators in Table 3 were selected with both responses in mind, which is why they rest on auditable quantities and include the terms on which collectors are engaged.

### ***The South African policy context***

South Africa illustrates both the policy relevance of the framework and the conditions under which its propositions could first be tested. The historical record shows a long sequence of ambitious waste instruments constrained by implementation capacity, particularly at municipal level [36,37]. The National Environmental Management: Waste Act 59 of 2008 established the legal basis for waste planning and for industry waste management schemes [33], and the National Waste Management Strategy 2020 elevated waste diversion, the circular economy and the integration of waste pickers to explicit policy objectives [34]. For most of the past two decades, however, producer responsibility for packaging operated through voluntary, industry-led schemes whose coverage and accountability were uneven [53]. The Extended Producer Responsibility Regulations of 2020 changed that position by making producer responsibility schemes mandatory for specified product classes [27], and the Waste Picker Integration Guideline for South Africa, issued in the same year, set out how informal collectors should be incorporated into municipal and industry systems [28].

These developments map directly onto the framework. The informal sector's contribution is substantial: Godfrey [54] estimates that informal reclaimers supplied about 51% of the paper and packaging waste collected in South Africa in 2017, and that payments from the private sector to the informal sector grew from approximately ZAR 625 million in 2012 to ZAR 872 million in 2017. Buy-back centres add value by upgrading recyclables to industry specifications and form the main interface between collectors and processors [55]. Yet landfill management practices continue to determine whether waste pickers are recognised or excluded, with direct

consequences for their livelihoods [45]. In the terms of the framework, the EPR regulations create a channel through which a hybrid capital structure and policy co-creation can operate, while the integration guideline provides a template for the contracted collector relationships on which Proposition P1 depends [27,28,54].

The implication for ventures is that policy engagement should be directed at municipal implementation rather than at national policy alone, because feedstock access and collection arrangements are determined at municipal level [28,36,45]. The implication for policymakers is that stability matters more than generosity. An instrument of modest value that survives a political cycle supports investment better than a generous instrument that may be withdrawn, because a venture's planning horizon is set by the least certain element in its environment [48,53]. The South African experience also cautions against assuming that formal regulation automatically benefits informal collectors, since the redistribution of value under EPR depends on how schemes contract with collectors and buy-back centres in practice [54,55].

### ***Practical implications and pathway to validation***

For entrepreneurs, the framework implies that the sequence in which problems are solved matters more than the quality of the solution to any one of them. Securing feedstock through organised collector relationships before raising expansion capital, rather than afterwards, aligns the binding constraint with the instrument [16,24]. For investors and development finance institutions, it implies that due diligence should examine the composition of the capital structure and the security of feedstock arrangements rather than technology differentiation, which the evidence suggests is rarely the binding constraint [5,21]. It also implies that impact claims should be appraised on auditable material flows and on the terms of collector engagement, as Section 3.7 argued [14,19]. For municipalities and regulators, it implies that contracting with organised collectors and buy-back centres, and publishing the resulting material-flow data, are low-cost actions that strengthen the feedback loop in Figure 1 [28,47].

Because the framework is conceptual, its validation is a necessary next step, and three complementary stages are proposed. The first is content validation through a Delphi panel of entrepreneurs, investors, municipal officials and waste picker representatives, which would test whether the components and indicators are complete and meaningful to practitioners [56]. The second is a comparative case study of matched ventures that did and did not replicate, selected by theoretical sampling within the four business model configurations, to examine whether the mechanisms operate as specified [57]. The third is a configurational test of the propositions on a defined venture population. Because the framework predicts that enablers act jointly through orchestration rather than independently, fuzzy-set qualitative comparative analysis is better suited than conventional regression for identifying the combinations of conditions associated with replication [58,59]. The venture population could be assembled from venture registries, development finance portfolios, municipal contract records and, in South Africa, the reporting obligations that the EPR regulations place on producer responsibility organisations [27]. These sources identify ventures without relying on the self-selection that investor databases introduce. Feedstock contracting and capital composition are observable from filings and funding announcements, regulatory engagement from consultation records, and collector arrangements from ventures' own reporting.

### ***Limitations***

Three limitations bound the article and should govern how its claims are read. First, it is conceptual: the framework organises existing evidence rather than testing hypotheses against new data, and the propositions remain untested. Second, the evidence base is uneven across regions; the literature on informal-sector integration is better developed for Latin America and parts of Africa and Asia than for other emerging markets [7,22], so the framework's generality is

an assumption rather than a demonstrated property. Third, the unit of analysis is difficult to bound, because ventures differ in how much of the value chain they operate, and a framework that applies fully to an integrated processor may apply only partially to a platform intermediary [40,42]. The validation pathway described above is designed to address all three limitations.

## **Conclusions**

Waste-to-wealth ventures in emerging markets operate in conditions that differ in kind from those in which circular economy theory was largely developed. Existing informal circularity, fragmented feedstock and uneven regulatory implementation constitute a distinct operating environment rather than an immature version of a mature one. This article has argued that scaling in that environment, defined as replication rather than valuation, depends on three enablers (an adaptive business model, a hybrid capital structure and policy co-creation) that act through the orchestration of an ecosystem that includes the informal collectors on whom feedstock security ultimately rests. It has further argued that the binding constraint changes as a venture moves from validation through consolidation and replication to regional scale, so that support instruments must be matched to stage rather than offered uniformly. The contribution lies in converting a literature of case narratives into a structure with identifiable components, stated indicators, a defined sequence and four falsifiable propositions. For policy, the South African experience with mandatory extended producer responsibility and waste picker integration shows that the conditions the framework identifies are already being shaped by regulation, and that their benefits depend on municipal implementation and on the terms on which collectors are engaged. Future research should test the propositions through the staged validation pathway proposed here, beginning with expert consultation and comparative case studies and proceeding to configurational analysis of a defined venture population.

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