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Strengthening Community Resilience through Circular Micro-Enterprise Development and Participatory Waste-to-Value Innovation

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Abstract

Community-based micro-enterprises frequently face interconnected challenges involving limited economic resources, weak access to circular business opportunities, inadequate waste-management practices, and restricted capacity to convert locally available materials into sustainable economic value. This study aims to examine how participatory circular micro-enterprise development can strengthen community resilience by integrating waste identification, community participation, entrepreneurial development, and waste-to-value innovation into a locally grounded intervention. An applied community-engagement approach was implemented through participatory assessment, identification and mapping of locally generated waste streams, circular-economy capacity building, collaborative ideation, practical waste-to-value experimentation, and mentoring of participating micro-enterprises. The intervention was assessed through structured observations, participant assessments, enterprise-level indicators, and comparison of conditions before and after the intervention to identify changes in circular knowledge, entrepreneurial capability, waste utilization, innovation readiness, and community participation. The findings indicate that an integrated participatory approach can strengthen the capacity of micro-entrepreneurs to recognize waste as an economic resource, develop feasible circular value propositions, collaborate with community stakeholders, and incorporate resource-efficiency considerations into enterprise practices. The study contributes an applied community-development framework that connects circular entrepreneurship with resilience-building while emphasizing local knowledge, collective action, and practical innovation rather than technology adoption alone.

Keywords: *Circular economy, community resilience, micro-enterprises, participatory innovation, waste-to-value*

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INTRODUCTION

The accelerating transition toward a circular economy has repositioned waste from an end-of-life liability into a potential productive resource, while small and micro-enterprises are increasingly recognized as important intermediaries for translating circular principles into locally embedded economic activities. Recent scholarship indicates that circular business models can simultaneously reshape resource utilization, innovation processes, stakeholder relationships, and sustainability performance, particularly when enterprises are able to connect environmental objectives with viable mechanisms of value creation (Araujo Galvão et al., 2022; Hina et al., 2022; Tapaninaho & Heikkinen, 2022). For small and medium-sized enterprises, however, circular transformation remains substantially more complex than the adoption of isolated recycling or waste-reduction practices because it requires organizational capabilities, entrepreneurial orientation, stakeholder coordination, and the capacity to redesign how value is generated and captured (Gennari, 2023; Alcalde-Calonge et al., 2024). This tension is particularly consequential in community-based economies, where micro-enterprises operate within highly localized resource systems and may simultaneously face financial constraints, limited technological capabilities, fragmented markets, and exposure to environmental risks.

Empirical research increasingly demonstrates that circular entrepreneurship can strengthen economic, social, and environmental outcomes when resource recovery is integrated into broader innovation and business strategies rather than treated as a narrowly technical waste-management intervention. Evidence from Mexican SMEs, for instance, associates circular economy principles and

sustainability-oriented innovation with improvements across social, economic, and environmental dimensions, suggesting that circularity can function as a strategic mechanism for enterprise development rather than merely an environmental compliance agenda (Rodríguez-Espíndola et al., 2022). Comparable research on SMEs emphasizes that social capital, adaptive capacity, and entrepreneurial orientation can facilitate the transition toward circular business models, indicating that the success of circular initiatives depends partly upon relationships and capabilities embedded within the surrounding business ecosystem (Alcalde-Calonge et al., 2024). Yet, the literature also identifies persistent barriers involving resources, knowledge, organizational readiness, market conditions, and institutional coordination, which can prevent smaller enterprises from converting circular opportunities into sustained commercial practices (Geissdoerfer et al., 2023; Rupeika-Apoga & Petrovska, 2022).

Waste-management initiatives in Indonesia provide an important empirical context for examining these dynamics because community participation has already become a significant mechanism through which waste collection, sorting, recovery, and socioeconomic empowerment can be connected. Studies of waste banks show that collaborative governance can influence implementation outcomes, while community-based circular-economy initiatives can become embedded within polycentric waste-governance arrangements when local actors are given meaningful institutional roles (Abdillah et al., 2022; Istiyani & Handayani, 2022). Research on Indonesian waste banks further indicates that waste-management activities may generate socioeconomic value and empowerment, while electronic-waste models demonstrate the potential for specialized recovery systems to contribute to circular-economy implementation (Miftahorrozi et al., 2022; Rimantho et al., 2022). Nevertheless, these approaches frequently remain centered on collection, segregation, recycling, or governance, leaving comparatively less attention to the entrepreneurial mechanisms through which recovered materials can be transformed into products, services, income streams, and locally retained economic value.

A particularly important gap concerns the relationship between community resilience and the development of micro-enterprises capable of converting waste into economically productive resources through participatory innovation. Existing circular-economy research has generated sophisticated frameworks for business-model innovation and circular supply chains, but much of the evidence concentrates on established SMEs, manufacturing systems, or formal organizational settings rather than economically vulnerable community-based micro-enterprises (Maher et al., 2023; Bhattacharya et al., 2024). Similarly, research on circular business ecosystems emphasizes interconnected actors and emerging forms of value creation, yet it does not fully explain how communities with limited resources can collectively identify locally available waste streams, develop feasible micro-enterprise opportunities, and institutionalize those opportunities as resilient livelihood strategies (Denicolai et al., 2023; Zhaksybayeva et al., 2024). The resulting conceptual fragmentation leaves unresolved whether participatory waste-to-value innovation should be understood primarily as a waste-management mechanism, an entrepreneurial intervention, a community-development strategy, or an integrated pathway connecting all three.

The empirical problem becomes more pronounced when circularity is considered at the level of everyday community economic practices, where the availability of recyclable materials does not automatically translate into viable entrepreneurial opportunities. Local actors require mechanisms for identifying material flows, understanding existing capabilities, coordinating complementary activities, assessing market opportunities, and determining how recovered resources can be incorporated into financially sustainable business models (Amin et al., 2022; Rittershaus et al., 2023). Research on circular business models suggests that absorptive capacity and knowledge acquisition are important antecedents of circular transformation, while stakeholder relationships influence the ability of enterprises to create value from circular activities (Marrucci et al., 2022; Tapaninaho & Heikkinen, 2022). At the community level, this implies that resilience cannot be reduced to the quantity of waste diverted from disposal, because meaningful resilience also depends on whether local actors acquire the collective capabilities required to transform environmental challenges into durable economic opportunities.

Participation provides a potentially important bridge between these dimensions because it enables local knowledge, material realities, and entrepreneurial aspirations to become inputs into the design of circular interventions rather than treating communities as passive recipients of externally designed programs. Participatory approaches have been used to strengthen local identification of resources and spatial-economic potentials, including community-based socioeconomic mapping and participatory

initiatives for improving the utilization of local environmental assets (Ariyanto, 2023; Makailipessy et al., 2023). Evidence from Indonesian batik communities similarly indicates that business-actor participation can contribute to the implementation of circular-economy principles within localized production systems, although participation alone does not guarantee the emergence of economically viable circular enterprises (Wijaya et al., 2024). The critical issue is therefore not simply whether communities participate, but whether participation is organized as a structured innovation process through which waste resources, entrepreneurial capabilities, market possibilities, and collective institutional arrangements are translated into actionable waste-to-value enterprises.

This study positions community-based circular micro-enterprise development as an integrated process in which environmental resource recovery, entrepreneurial capability formation, participatory innovation, and collective resilience are mutually reinforcing rather than analytically isolated domains. The approach responds to evidence that circular transitions among smaller firms require combinations of organizational capability, innovation orientation, stakeholder engagement, and supportive ecosystems, while Indonesian experiences demonstrate the practical relevance of community-centered waste governance and local economic participation (Agyabeng-Mensah et al., 2024; Alcalde-Calonge et al., 2024; Nohong et al., 2024). It also extends the prevailing emphasis on waste banks and circular supply chains by focusing on the entrepreneurial conversion of locally available waste into products, services, and income-generating activities through a participatory process. Such a perspective places community resilience at the intersection of circular resource management and livelihood development, allowing resilience to be examined not merely as resistance to environmental disruption but as the capacity of local economic actors to adapt, innovate, collaborate, and create value from constrained resource conditions.

Against this background, the study aims to develop and examine a community-based model of circular micro-enterprise development through participatory waste-to-value innovation, with particular attention to how local actors identify waste resources, formulate enterprise opportunities, develop circular products or services, and strengthen collective capabilities for sustained economic participation. The study contributes theoretically by connecting circular-economy business-model thinking with community resilience and participatory entrepreneurship, thereby conceptualizing waste-to-value activity as a socio-economic process rather than a purely technical waste intervention. Methodologically, it contributes an integrated community-oriented approach that links participatory identification of local waste resources with entrepreneurial experimentation, collaborative capability building, and assessment of emerging economic value. Practically, the study seeks to provide communities, micro-enterprises, local institutions, and development practitioners with an actionable basis for transforming locally generated waste into productive resources while strengthening inclusive livelihood opportunities and longer-term community capacity.

METHODS

This study employed a participatory action research (PAR) design to examine how community actors could collectively identify, evaluate, and develop circular micro-enterprise opportunities through waste-to-value innovation. The research was conducted through four interconnected stages: community diagnosis, participatory waste-resource mapping, circular enterprise co-design, and action-reflection. Data were generated from field observations, semi-structured interviews with micro-enterprise actors and community stakeholders, participatory workshops, and direct documentation of locally available waste streams and their existing uses. The participatory mapping process recorded the type, approximate volume, source, current disposal or recovery pathway, potential reuse, and actors involved in each major waste stream, while interviews explored existing entrepreneurial capabilities, perceived barriers, access to markets, resource constraints, and community preferences concerning potential circular businesses. Rather than treating community members as research subjects, the PAR framework positioned them as co-researchers who participated in identifying problems, interpreting local resource conditions, selecting feasible intervention opportunities, and refining proposed enterprise models through iterative discussion and collective reflection.

The empirical analysis combined material-flow assessment, qualitative thematic analysis, and circular business model prototyping to establish the relationship between waste availability and community-level entrepreneurial opportunities. Material-flow data were organized according to waste categories, sources, estimated recoverability, existing utilization, and potential value-adding pathways,

after which the most feasible opportunities were selected through participatory prioritization based on resource availability, technical feasibility, required investment, market potential, environmental contribution, and community acceptance. Qualitative data from interviews, observations, and workshop discussions were coded thematically to identify changes in participants' perceptions of waste, barriers to circular entrepreneurship, mechanisms of collective action, and forms of capability development emerging during the intervention. The selected opportunities were subsequently translated into circular micro-enterprise prototypes specifying input materials, processing activities, products or services, target customers, value propositions, community roles, revenue mechanisms, and potential environmental benefits, followed by an action-reflection session in which participants evaluated feasibility and proposed modifications. Research quality was strengthened through triangulation across observation, interview, mapping, and participatory workshop evidence, while the analysis emphasized the processes through which local knowledge and collective action contributed to the formation of economically and environmentally viable waste-to-value initiatives.

RESULTS AND DISCUSSION

Baseline Conditions and Participatory Capacity Building of Micro-Entrepreneurs

The initial assessment indicated that the participating micro-enterprises operated within a relatively fragile entrepreneurial environment in which economic activity, household livelihood strategies, and environmental management were closely intertwined. The program involved 60 vulnerable micro-enterprises whose business activities included food processing, household products, informal retail, handicrafts, clothing, and small-scale recycling-related activities, providing a sufficiently heterogeneous setting for examining how circular practices could be integrated into existing livelihood systems rather than introduced as an entirely separate economic activity. The baseline assessment focused on entrepreneurial characteristics, access to productive resources, existing waste-handling practices, familiarity with circular-economy principles, and the capacity to identify economic value in discarded materials. This approach is consistent with the argument that circular transformation in smaller enterprises depends not only on technological adoption but also on organizational readiness, entrepreneurial orientation, adaptive capacity, and social capital (Alcalde-Calonge et al., 2024; Gennari, 2023).

The participant profile revealed a predominance of micro-scale operators with limited managerial formalization, indicating that circular entrepreneurship could not be approached through capital-intensive business transformation models alone. As presented in Table 1, 63.3% of participants were women, while 36.7% were men, and approximately two-thirds had operated their businesses for between two and six years; 71.7% reported that their enterprises constituted either the primary or an important supplementary source of household income. The relatively high proportion of informal or semi-formal businesses reinforces the importance of designing interventions around existing capabilities, social relationships, and locally available resources rather than assuming the presence of sophisticated managerial systems. This finding corresponds with the broader literature showing that the transition toward circular business models among SMEs is constrained by resource limitations, knowledge gaps, organizational capabilities, and difficulties in translating circular principles into economically viable routines (Hina et al., 2022; Geissdoerfer et al., 2023).

Table 1. Baseline Characteristics Of Participating Micro-Enterprises

Indicator	Category	n	%
Gender of enterprise operator	Female	38	63.3
	Male	22	36.7
Age	20–29 years	11	18.3
	30–39 years	21	35.0
	40–49 years	19	31.7
	≥50 years	9	15.0

Indicator	Category	n	%
Business experience	<2 years	12	20.0
	2–6 years	39	65.0
	>6 years	9	15.0
Main business sector	Food/beverage	21	35.0
	Retail/trading	14	23.3
	Craft/creative products	10	16.7
	Household production	8	13.3
	Recycling/waste-related	7	11.7
Business as household income source	Primary	31	51.7
	Supplementary but important	12	20.0
	Supplementary/minor	17	28.3
Existing waste separation practice	Regular	13	21.7
	Occasional	18	30.0
	Rare/none	29	48.3

The most pronounced baseline limitation concerned the gap between participants' general awareness of environmental problems and their ability to translate that awareness into entrepreneurial practice. Although 68.3% recognized that waste could potentially be reused or sold, only 21.7% reported regularly separating business-related waste, while fewer than one-quarter maintained any systematic record of waste types, quantities, or potential resale values. This distinction is important because circularity requires more than positive environmental attitudes; it requires routines that allow materials, information, and economic value to circulate within a business system. Amicarelli et al. (2023) demonstrate the importance of measurable circularity indicators, while Marrucci et al. (2022) emphasize absorptive capacity as an antecedent of circular business-model development, suggesting that awareness becomes economically consequential only when enterprises possess mechanisms for identifying, absorbing, and applying relevant knowledge.

The participatory capacity-building sessions therefore emphasized practical recognition of material flows rather than relying exclusively on conventional environmental education. Participants were asked to document the materials entering and leaving their businesses, distinguish reusable from recyclable and residual materials, identify potential downstream users, and estimate the economic value associated with selected waste categories. The intervention treated waste as a potential productive input and information resource, enabling participants to connect environmental practices with procurement, production, inventory management, and revenue generation. Such an approach corresponds with circular-business research arguing that value creation depends on reconfiguring relationships among resources, stakeholders, and business activities rather than merely reducing the volume of waste produced (Tapaninaho & Heikkinen, 2022; Araujo Galvão et al., 2022).

The pre- and post-intervention assessment suggests that the participatory training substantially improved participants' operational understanding of circular entrepreneurship. As shown in Table 2, the average composite capacity score increased from 42.8 to 78.6 on a 100-point scale, representing a 35.8-point absolute improvement. The strongest improvement occurred in waste classification and material-value identification, while the smallest relative improvement concerned formal circular business planning, which remained more demanding because it required participants to integrate several newly acquired competencies into a coherent business model. The pattern is compatible with Maher et al. (2023), who conceptualize SME circular transformation as a structured process requiring practical organizational adaptation rather than a single technological intervention.

Table 2. Changes In Circular Entrepreneurship Capacity Before and After Intervention

Capacity indicator	Pre-test mean	Post-test mean	Absolute change	Relative improvement (%)
Understanding of circular economy	46.7	82.3	+35.6	76.2
Waste classification	49.2	86.7	+37.5	76.2
Identification of material value	38.5	81.8	+43.3	112.5
Circular production planning	39.8	73.5	+33.7	84.7
Circular business-model understanding	34.6	70.8	+36.2	104.6
Stakeholder identification	43.7	78.9	+35.2	80.5
Circular record keeping	31.9	72.4	+40.5	126.9
Composite capacity score	42.8	78.6	+35.8	83.6

The particularly strong improvement in material-value identification and circular record keeping is theoretically significant because it indicates movement from abstract environmental awareness toward operational capability. Participants learned to classify waste according to material type, condition, quantity, and potential market destination, thereby creating a rudimentary information system for circular decision-making. This outcome resonates with Agyabeng-Mensah et al. (2024), who link circular practices to information exchange capability and circular innovation orientation, while García-Buendía et al. (2024) similarly emphasize information integration as a central issue in circular supply-chain development. At the micro-enterprise level, the ability to record material flows can function as a low-cost substitute for more sophisticated information systems and provide an initial foundation for subsequent digitalization.

The qualitative mentoring records further indicated that participants initially tended to conceptualize waste management as an environmental responsibility external to their core business activities, whereas subsequent discussions increasingly connected waste with purchasing decisions, product design, production costs, and potential secondary revenue. This shift was particularly visible among food processors and craft producers, who identified organic residues, packaging materials, textile remnants, and rejected products as resources that could either be reused internally or redirected to other local actors. Such reinterpretation is consistent with Rodríguez-Espíndola et al. (2022), who associate circular principles and sustainability-oriented innovation with improved social, economic, and environmental performance among SMEs. The intervention thus positioned circularity as an entrepreneurial capability rather than merely a waste-management obligation.

The results also suggest that social interaction played a critical role in reducing the perceived complexity of circular transformation. Participants exchanged practical knowledge regarding suppliers, collectors, processors, craft producers, and potential customers, allowing knowledge that was previously fragmented across individual businesses to become a shared community resource. This social dimension supports the finding of Alcalde-Calonge et al. (2024) that social capital and adaptive capacity can facilitate circular-economy adoption among SMEs, while Denicolai et al. (2023) conceptualize circular business ecosystems as networks in which digitalization, sustainability, and inter-organizational relationships increasingly interact. In this context, the intervention's principal contribution was not simply to increase individual knowledge but to strengthen the relational infrastructure through which circular knowledge could circulate.

The capacity-building process nevertheless revealed that not all circular practices were equally accessible to participants. Activities requiring specialized equipment, substantial upfront investment, or reliable downstream buyers remained difficult for micro-enterprises with limited liquidity, whereas low-cost practices such as segregation, reuse, repair, repackaging, and material exchange were more readily adopted. This pattern is consistent with the barriers identified by Hina et al. (2022) and Geissdoerfer et al. (2023), who show that circular business-model innovation is influenced by financial, organizational, technological, and market constraints. The results consequently support a graduated

model of community circular entrepreneurship in which enterprises initially strengthen low-cost internal capabilities before progressing toward more sophisticated circular business arrangements.

Participatory Waste Mapping and Development of Waste-to-Value Opportunities

The second intervention stage transformed the knowledge generated during capacity building into a participatory mapping process designed to identify material sources, accumulation points, potential processors, existing waste-management actors, and opportunities for value creation. Rather than treating mapping as a purely geographical exercise, the program combined spatial information with entrepreneurial knowledge regarding the quantity, quality, seasonality, and potential destination of waste materials. Participants collaboratively identified 47 relevant material-flow points within the local economic area, consisting of household sources, micro-enterprises, collection points, informal collectors, small processors, and potential product-making groups. This approach reflects the methodological argument that participatory mapping can produce locally grounded knowledge that is difficult to obtain through externally designed datasets alone (Denwood et al., 2022; Laituri et al., 2023).

The resulting map revealed that waste generation and potential value were spatially uneven, with food-related organic materials concentrated around food businesses and markets, while plastic packaging, cardboard, textile remnants, and used cooking oil were distributed across retail, household, and service activities. Participants initially perceived these streams as separate problems, but mapping made it possible to identify potential complementarities between businesses. For example, packaging waste generated by one enterprise could become a raw material for another, while organic residues could potentially be redirected toward composting or other biological processing activities. This spatial-economic interpretation extends the logic of circular supply-chain analysis by demonstrating that resource circulation can be organized around community-level proximity rather than solely around formal industrial networks (Amin et al., 2022; García-Buendía et al., 2024).

Table 3. Participatory Mapping of Local Material-Flow Opportunities

Material stream	Main source	Identified local actors	Monthly estimated volume	Potential circular use
PET bottles	Food/retail	11	1,420 kg	Reprocessing, crafts
Cardboard/paper	Retail	9	980 kg	Reuse, packaging
Used cooking oil	Food businesses	8	610 L	Collection and processing
Organic residues	Food businesses/market	14	2,350 kg	Compost/biological processing
Textile remnants	Tailoring/crafts	7	420 kg	Upcycling
Glass containers	Food/household	6	290 kg	Reuse/refilling
Metal cans	Retail/food	5	185 kg	Scrap recycling
Mixed low-value plastics	Household/business	12	760 kg	Aggregation/downstream processing
Total	—	—	7,015 kg + 610 L	—

The participatory mapping exercise identified a total estimated monthly material flow of 7,015 kg of solid materials plus approximately 610 liters of used cooking oil across the mapped economic area. The figures demonstrate the potential scale of material resources available to community-based circular enterprises, although the mapping data should be understood as locally estimated rather than equivalent to a formal waste audit. The distinction matters because participatory estimates are influenced by participant recall, seasonal conditions, and the availability of records, issues that have been highlighted in research examining the reliability and contextuality of participatory spatial data (Brisudova et al., 2024). Even with this limitation, the mapping process generated actionable information that was previously unavailable to individual businesses.

The most important outcome of the mapping exercise was the identification of material combinations capable of supporting small-scale waste-to-value activities. Three priority opportunity clusters emerged: plastic-based products, organic-resource processing, and textile/material upcycling. Participants proposed products including reusable containers, decorative items, simple household accessories, compost-based inputs, and upcycled textile products, while the program emphasized that product selection should follow identifiable material availability and market demand rather than the assumption that every waste stream must be transformed into a new product. This approach is compatible with Rittershaus et al. (2023), who argue that SMEs require systematic mechanisms for screening appropriate circular business models rather than adopting circularity indiscriminately.

The mapping process also exposed a critical distinction between the physical availability of waste and the economic availability of usable materials. A material could be abundant but commercially unattractive if it was contaminated, mixed, difficult to transport, or lacked a reliable buyer, whereas smaller quantities of clean and consistently sorted materials could generate higher value. Participants therefore developed a simple prioritization framework combining volume, material quality, collection cost, processing difficulty, and potential market demand. This finding is consistent with Cahayani et al. (2023), whose analysis of plastic-waste value maximization demonstrates that circular-economy performance depends not merely on the quantity of waste recovered but on the mechanisms through which materials are converted into economically meaningful value.

The participatory character of the mapping process was particularly important because external facilitators could not independently determine the most viable material pathways. Local actors possessed knowledge concerning collection schedules, seasonal fluctuations, informal trading practices, customer preferences, and existing relationships with collectors that was not captured in conventional administrative datasets. Nurminen et al. (2024) demonstrate that participatory mapping can influence planning by incorporating situated knowledge into decision-making, while Pitidis et al. (2024) emphasize the importance of dialogical mapping for developing more equitable resilience imaginaries in communities facing structural vulnerabilities. The present intervention applies this logic to micro-enterprise development by positioning local economic actors as producers of circular-economy knowledge rather than passive recipients of technical solutions.

The mapping process also supported the emergence of a community-level network connecting 60 micro-enterprises with 17 material collectors, eight potential processors, six craft groups, and five local institutions. This network created a preliminary circular ecosystem in which actors could exchange materials, information, and potential market opportunities. Such network formation corresponds with Tapaninaho and Heikkinen (2022), who conceptualize circular value creation through stakeholder relationships, and with Denicolai et al. (2023), who highlight the ecosystem character of emerging circular business configurations. At the community scale, these relationships reduce the isolation of individual micro-enterprises and create possibilities for collective procurement, aggregation, processing, and marketing.

Table 4. Priority Waste-To-Value Initiatives Developed Through Participatory Mapping

Initiative	Participating enterprises	Initial investment category	Expected material utilization	Business feasibility score (0–100)
Plastic sorting and aggregation	18	Low	1,420 kg/month	82
Upcycled textile products	12	Low–medium	420 kg/month	78
Organic waste composting	16	Medium	2,350 kg/month	76
Used cooking-oil collection	9	Low	610 L/month	74
Reusable packaging system	14	Medium	980 kg/month	71

Initiative	Participating enterprises	Initial investment category	Expected material utilization	Business feasibility score (0–100)
Glass-container reuse	7	Low	290 kg/month	69
Community material exchange	23	Low	Multiple streams	85
Mixed-plastic processing	8	Medium–high	760 kg/month	61

The highest feasibility score was assigned to the community material-exchange initiative, followed by plastic sorting and aggregation, because these activities required relatively limited capital while immediately addressing information and coordination failures. The finding suggests that the first stage of circular entrepreneurship in vulnerable communities may be more effectively supported through coordination and aggregation than through sophisticated processing technologies. Maher et al. (2023) similarly demonstrate that SME circularity can be structured through staged interventions that combine business-process changes with practical technological and organizational adaptations. The result also corresponds with Araujo Galvão et al. (2022), who identify barriers to circular business models that can be reduced when organizations redesign value creation around resource recovery and stakeholder cooperation.

A further finding was that participants increasingly differentiated between activities that generated direct financial value and activities that created enabling value for other circular enterprises. For example, sorting and aggregation did not always generate high margins at the individual enterprise level, but they reduced contamination and improved material quality for downstream users, while shared collection systems reduced transaction costs for multiple businesses simultaneously. This reflects the broader argument of Bhattacharya et al. (2024) that circular supply chains require coordination across multiple stages rather than isolated improvements within individual firms. The participatory mapping therefore generated a more systemic understanding of circular entrepreneurship in which the viability of one micro-enterprise could depend upon complementary activities undertaken by other community actors.

The mapping stage also revealed governance challenges, particularly concerning responsibility for collection, quality standards, price determination, and continuity of supply. Participants reported that previous informal exchanges often depended on personal relationships and lacked transparent rules, creating uncertainty when material prices changed or collectors became unavailable. Evidence from Indonesian waste-bank systems indicates that collaborative governance can strengthen implementation by clarifying responsibilities among communities, local government, and other actors (Abdillah et al., 2022; Fatmawati et al., 2022), while Istiyani and Handayani (2022) show that community-based circular initiatives can operate within polycentric governance arrangements. The present findings reinforce the importance of institutionalizing at least basic coordination mechanisms if community waste-to-value activities are expected to persist beyond the intervention period.

The participatory mapping approach ultimately converted dispersed local knowledge into a shared economic-resource map that could be used for subsequent mentoring and enterprise planning. Its contribution lies less in producing a technically sophisticated geographic information system than in establishing a common reference point through which community members could discuss resource flows, bottlenecks, opportunities, and responsibilities. Denwood et al. (2023) demonstrate that participatory mapping can be made accessible without sacrificing analytical potential, a principle particularly relevant for communities where technical GIS expertise is limited. The resulting map therefore functioned simultaneously as a planning instrument, a learning device, and a mechanism for coordinating local circular entrepreneurship.

Waste-to-Value Innovation, Enterprise Resilience, and Community-Level Sustainability

The third stage examined whether the combination of circular-capacity development, participatory mapping, and mentoring could translate into observable changes in enterprise resilience and waste-to-value practices. Rather than defining resilience exclusively as the ability to maintain

revenue during economic shocks, the evaluation conceptualized resilience as the capacity to identify alternative resources, diversify value-creation pathways, adapt production practices, maintain stakeholder relationships, and respond to changes in market or material availability. This multidimensional interpretation is consistent with Kumar et al. (2023), who identify technological, organizational, and relational factors as important enablers of SME resilience, and with the broader circular-business literature that links resource efficiency with adaptive capacity. The intervention consequently assessed resilience through behavioral and organizational indicators rather than relying solely on short-term financial performance.

Following the mentoring period, the number of enterprises regularly separating potentially valuable materials increased from 13 to 49, while the number maintaining a basic material-flow record increased from 9 to 44. Participants also reported greater use of recovered or reused materials in production and packaging, although the scale of adoption varied considerably across sectors. These changes suggest that mentoring was important because training alone did not automatically produce sustained behavioral change; participants required repeated assistance in adapting the principles to their specific production routines. The observation is consistent with the literature emphasizing that circular transformation is a process of organizational learning rather than a discrete adoption decision (Gennari, 2023; Marrucci et al., 2022).

Table 5. Enterprise-Level Changes Following Mentoring

Indicator	Before intervention n (%)	After mentoring n (%)	Change
Regular material separation	13 (21.7)	49 (81.7)	+60.0 pp
Basic material-flow records	9 (15.0)	44 (73.3)	+58.3 pp
Reuse of materials in production	11 (18.3)	37 (61.7)	+43.4 pp
Sale of segregated materials	15 (25.0)	42 (70.0)	+45.0 pp
Collaboration with other enterprises	14 (23.3)	39 (65.0)	+41.7 pp
Use of reusable/recovered packaging	8 (13.3)	31 (51.7)	+38.4 pp
Circular product experimentation	6 (10.0)	29 (48.3)	+38.3 pp
Monthly review of material costs	7 (11.7)	35 (58.3)	+46.6 pp

The most substantial change involved regular material separation, which increased by 60 percentage points, indicating that the intervention successfully translated a conceptual principle into a routine operational practice for a majority of participants. The corresponding increase in material-flow recording is particularly relevant because it provides an informational basis for evaluating whether circular practices generate actual economic benefits. Without records, enterprises may perceive reuse or recycling as environmentally desirable without knowing whether it reduces costs or generates additional income. This reinforces the importance of measurement and information exchange emphasized by Amicarelli et al. (2023) and Agyabeng-Mensah et al. (2024).

The mentoring records showed that enterprises adopting circular practices generally began with low-complexity activities before experimenting with more innovative product or service configurations. For instance, several food businesses initially reduced packaging waste through reuse and bulk procurement, subsequently exploring reusable-container systems, while craft producers began by collecting textile remnants before developing small product lines from recovered materials. This sequential pattern supports the view that circular innovation should be understood as an evolutionary process in which firms accumulate experience and absorptive capacity before undertaking more complex transformations. Marrucci et al. (2022) similarly emphasize the role of absorptive capacity in enabling SMEs to develop circular business models, while Araujo Galvão et al. (2022) identify organizational and market barriers that make gradual transition particularly relevant for smaller firms.

The intervention also generated measurable changes in the perceived resilience of participating enterprises. The composite resilience score increased from 44.1 before the program to 76.8 after mentoring, with the largest improvement occurring in resource diversification and the ability to identify alternative material suppliers or downstream users. The improvement should not be interpreted as proof

that the enterprises became objectively more resilient to all future shocks, because the observation period was relatively short and no external shock was deliberately introduced. It does, however, indicate that participants acquired a broader set of adaptive routines, consistent with the conceptualization of digital and organizational resilience as the capacity to prepare for, respond to, and adapt to changing conditions (Kumar et al., 2023).

Table 6. Changes In Community Micro-Enterprise Resilience Indicators

Resilience dimension	Pre-intervention	Post-intervention	Change
Resource diversification	41.8	76.9	+35.1
Ability to identify alternative suppliers	43.6	75.8	+32.2
Ability to identify alternative markets	45.2	72.4	+27.2
Cost awareness	47.5	78.6	+31.1
Collaboration capacity	46.1	79.8	+33.7
Material-flow monitoring	35.7	75.9	+40.2
Innovation readiness	42.9	73.5	+30.6
Community-network participation	48.2	80.7	+32.5
Composite resilience score	44.1	76.8	+32.7

The increase in community-network participation was particularly relevant because circular entrepreneurship depends on relationships extending beyond individual firms. Participants increasingly exchanged information about material availability, prices, potential buyers, product ideas, and processing options, effectively transforming the intervention into a local knowledge network. Such network effects are important because the economic value of recovered materials often depends on aggregation and coordination, particularly when individual enterprises generate quantities too small to negotiate directly with processors. Tapaninaho and Heikkinen (2022) identify stakeholder relationships as central to circular value creation, while Zhaksybayeva et al. (2024) emphasize the ecosystem dimension of circular business development.

The mentoring process also demonstrated that circular entrepreneurship can generate social benefits beyond direct enterprise profitability. Participants reported that shared collection activities reduced the time individual businesses spent searching for buyers, while group-based production experiments created opportunities for exchanging skills and distributing tasks according to participant capabilities. In this sense, the waste-to-value model generated forms of collective efficiency that were not visible when enterprises operated independently. Miftahorrozi et al. (2022) similarly connect waste-bank activity in Indonesia with socioeconomic empowerment, while Jaya and Machdum (2022) illustrate how waste-bank systems can function as institutional mechanisms linking waste management with community-level circular-economy practices.

The results further suggest that circular micro-enterprise development should be connected with broader community waste-management systems rather than implemented as isolated entrepreneurial projects. Existing waste-bank and community-management models provide potential downstream channels for material aggregation, while micro-enterprises can provide demand for selected recovered materials and create additional products or services from them. Evidence from Indonesia shows that community-based waste governance can be strengthened through collaboration among residents, local institutions, and waste-management actors (Abdillah et al., 2022; Istiyani & Handayani, 2022), while Rimantho et al. (2022) demonstrate the potential of specialized waste-bank models for integrating waste recovery with circular-economy implementation. The present intervention adds an enterprise-development dimension by positioning micro-businesses not only as waste generators but also as potential users, processors, aggregators, and value creators.

The innovation process nevertheless remained constrained by access to markets, equipment, quality standards, and stable downstream demand. Participants could identify many potential products from waste materials, but only a smaller proportion progressed to consistent production because experimentation involved additional labor and uncertainty regarding customer acceptance. This finding

mirrors the barriers documented by Geissdoerfer et al. (2023) and Hina et al. (2022), particularly the difficulties SMEs face in converting circular concepts into commercially viable business models. The results therefore indicate that community capacity building is a necessary but insufficient condition for circular enterprise development; sustained market linkage and institutional support remain important for converting experimentation into durable economic activity.

The economic dimension of the intervention was also reflected in changes in the way participants perceived waste-related costs and revenues. Before the program, waste was generally treated as an unavoidable operating expense or a household/community problem, whereas after mentoring participants increasingly identified three possible economic pathways: avoiding costs through reuse, generating supplementary revenue through material sales, and creating new products from recovered resources. This conceptual shift is consistent with Rodríguez-Espíndola et al. (2022), who link circular principles with social, economic, and environmental performance, and with Cahayani et al. (2023), who demonstrate the importance of mechanisms that maximize the economic value of recovered materials. The principal outcome was therefore not simply increased recycling but a redefinition of waste as a potentially productive resource within local economic systems.

The findings also provide a basis for connecting community circularity with sustainability objectives at the enterprise and territorial levels. At the enterprise level, resource reuse and material monitoring can reduce unnecessary input costs and improve operational awareness; at the community level, coordinated collection can reduce material leakage and create new livelihood opportunities; and at the system level, stronger relationships among enterprises, collectors, processors, and institutions can increase the circulation of resources within the local economy. Ozturk et al. (2024) demonstrate the broader relationship between enterprise digitalization and sustainable development, while Tanveer and Hoang (2024) show that procurement relationships can influence the emergence of circular business models. The present findings suggest that similar relational mechanisms can be cultivated at a much smaller community scale through participatory intervention.

The overall evidence indicates that community resilience is strengthened not by a single circular technology or waste-processing activity but by the combination of knowledge, material visibility, stakeholder coordination, entrepreneurial experimentation, and repeated mentoring. This integrated mechanism is important because isolated interventions can produce temporary behavioral changes without establishing the organizational and relational conditions needed for continuation. The results are broadly compatible with the circular-business framework developed by Maher et al. (2023), the SME transition perspective of Gennari (2023), and the ecosystem orientation emphasized by Denicolai et al. (2023). The contribution of the intervention therefore lies in connecting circular micro-enterprise development with participatory resource mapping and community-level innovation rather than treating waste management and entrepreneurship as separate domains.

Finally, the intervention provides evidence that vulnerable micro-enterprises can function as active agents in local circular-economy transitions when the intervention begins with their existing knowledge, networks, and material realities. The combination of participatory mapping and waste-to-value experimentation created a practical bridge between environmental management and livelihood development, while the mentoring component helped translate collective knowledge into enterprise-level routines. This approach is consistent with Wijaya et al. (2024), who document business-actor participation in circular-economy implementation in Indonesian batik production, and with Nohong et al. (2024), who highlight the importance of incentive structures for sustaining community and industry involvement in waste management. The findings consequently position community circular entrepreneurship as an institutional and social process in which resilience emerges from the capacity of multiple local actors to recognize, organize, and repeatedly circulate underutilized resources.

Synthesis of the Findings

Across the three analytical dimensions, the results indicate that the intervention operated through a mutually reinforcing sequence rather than through independent training components. Capacity building increased participants' ability to recognize circular opportunities, participatory mapping made local material flows and potential actors visible, and mentoring supported the translation of those opportunities into repeated enterprise practices. This sequence is important because the literature increasingly recognizes that circular transformation requires simultaneous attention to capabilities, organizational routines, stakeholder relationships, and resource flows rather than isolated

environmental interventions (Agyabeng-Mensah et al., 2024; Alcalde-Calonge et al., 2024; Bhattacharya et al., 2024). The study therefore provides a community-level interpretation of circular entrepreneurship in which resilience emerges through interaction between enterprise capabilities and local resource networks.

The results also demonstrate that the economic and environmental dimensions of circularity cannot be separated in vulnerable micro-enterprise contexts. Waste segregation became more meaningful when participants could connect it to avoided costs, supplementary income, product development, or relationships with other local enterprises, while entrepreneurial experimentation became more feasible when material availability and downstream pathways were mapped collectively. This reinforces the argument that circular-economy transitions require business models capable of simultaneously addressing resource efficiency and value creation (Araujo Galvão et al., 2022; Tapaninaho & Heikkinen, 2022). The intervention consequently contributes a practical model in which environmental action becomes economically relevant through community coordination rather than through large-scale technological investment.

At the same time, the results should not be interpreted as evidence that all participating enterprises achieved a complete transition to circular business models. Adoption remained uneven, capital-intensive activities were less accessible, and market uncertainty continued to restrict the scaling of several innovations, confirming the persistence of barriers identified in the broader circular-business literature (Hina et al., 2022; Geissdoerfer et al., 2023). The observed improvements are therefore better understood as increased circular capability and readiness rather than as definitive evidence of long-term circular transformation. This distinction is particularly important for community-engagement research, where short intervention periods can demonstrate learning and behavioral change but cannot independently establish long-term economic or environmental outcomes.

The findings further suggest that community resilience should be approached as an emergent property of relationships among micro-enterprises, households, collectors, processors, institutions, and local markets. Such a perspective extends conventional enterprise-level resilience models by emphasizing the role of shared resources, collective information, and decentralized coordination. The evidence from Indonesian waste-bank initiatives provides a relevant institutional context for this interpretation, demonstrating that community participation can become an important mechanism for linking waste management with socioeconomic empowerment (Miftahorrozi et al., 2022; Jaya & Machdum, 2022). Circular micro-enterprises can occupy an intermediary position within this system by transforming recovered materials into economic resources while simultaneously strengthening local demand for segregated materials.

The participatory mapping component also contributes methodologically by demonstrating that local economic mapping does not need to be technologically complex to become analytically useful. What matters is the ability of participants to collectively identify material sources, resource flows, bottlenecks, actors, and potential value pathways, while maintaining sufficient records to support subsequent decision-making. This corresponds with Denwood et al. (2022, 2023), Brisudova et al. (2024), and Laituri et al. (2023), whose work collectively emphasizes accessibility, contextual knowledge, data quality, and critical reflection in participatory mapping. For community-based circular development, mapping consequently becomes both a research method and an intervention mechanism.

The study further indicates that waste-to-value innovation can serve as a practical entry point for strengthening entrepreneurial capabilities among vulnerable micro-enterprises because it starts from resources already present within local economic systems. Rather than requiring participants to adopt entirely new sectors, the intervention encouraged them to reinterpret existing waste streams, production residues, packaging materials, and community relationships as potential inputs into new or modified business activities. Such incremental innovation is particularly relevant where financial resources are limited and large-scale technological investment is unrealistic. The findings are consistent with the broader evidence that circular innovation in SMEs is shaped by resource constraints, absorptive capacity, stakeholder pressure, and organizational readiness (Marrucci et al., 2022; Agyabeng-Mensah et al., 2024).

The practical implication is that community-based circular programs should move beyond one-off awareness campaigns and establish continuing mechanisms for information sharing, material aggregation, product experimentation, and market connection. Indonesian evidence on waste banks and community-based waste governance demonstrates that sustained participation depends on institutional

arrangements, incentives, and coordination rather than awareness alone (Abdillah et al., 2022; Fatmawati et al., 2022; Istiyani & Handayani, 2022). The present findings extend this perspective by showing how entrepreneurial actors can become part of the circular governance structure. Their participation potentially strengthens the economic rationale for material separation while simultaneously creating new local livelihood pathways.

From a sustainability perspective, the intervention also demonstrates the importance of connecting micro-enterprise development with broader resource-management systems. The circular economy becomes more resilient when material recovery, business innovation, stakeholder relationships, and local governance reinforce one another, rather than when each operates as a separate program. This systems perspective corresponds with the emerging literature on circular supply chains and business ecosystems, which stresses the importance of interdependence, information exchange, procurement, and coordination (García-Buendía et al., 2024; Tanveer & Hoang, 2024; Denicolai et al., 2023). The community scale provides a particularly relevant setting for examining these relationships because social proximity can reduce coordination barriers while enabling rapid experimentation.

Taken together, the findings position participatory waste-to-value innovation as a mechanism through which environmental resources can be converted into entrepreneurial learning, collaborative capacity, and community resilience. The central contribution is not the creation of a particular recycled product or waste-processing technique but the establishment of a process through which vulnerable micro-enterprises collectively recognize resources, map their circulation, experiment with value creation, and develop adaptive routines. This conceptualization responds to the continuing need for circular-economy approaches that are economically viable, socially embedded, and accessible to smaller enterprises. It also provides a foundation for subsequent longitudinal research examining whether the improvements observed during the intervention translate into sustained income diversification, measurable reductions in material leakage, stronger circular supply relationships, and durable community-level resilience.

CONCLUSION

This study demonstrates that strengthening community resilience through circular micro-enterprise development requires more than the introduction of waste-processing techniques or the promotion of environmentally responsible business practices. The central contribution of the intervention lies in connecting community participation, entrepreneurial capability, local material knowledge, and waste-to-value innovation within a single development process in which waste is repositioned from an environmental burden into a potential productive resource. The findings indicate that circularity becomes more meaningful at the community level when micro-entrepreneurs are able to identify locally available material streams, assess their economic potential, experiment with feasible value-creation pathways, and collectively organize the relationships required to sustain these activities. This perspective extends the understanding of community resilience by positioning circular entrepreneurship as both an economic adaptation mechanism and a locally embedded capacity for responding to resource constraints, environmental pressures, and changing livelihood conditions.

The implications of the study are relevant for community development practitioners, local governments, intermediary organizations, and micro-enterprise support programs seeking to operationalize circular-economy principles beyond large firms and formal industrial supply chains. Rather than treating waste management, entrepreneurship development, and environmental awareness as separate intervention domains, community programs can integrate them through participatory diagnosis, material-flow identification, experimentation, business-model development, and stakeholder coordination. Such an approach can also strengthen local ownership because the economic opportunities emerging from waste-to-value activities are derived from community knowledge and locally observable resource conditions rather than from externally imposed technological solutions. At the broader societal level, the study contributes a practical pathway through which communities can participate in resource recovery while simultaneously developing livelihood opportunities, collective problem-solving capacity, and more sustainable patterns of local production and consumption.

The interpretation of these contributions is subject to several boundaries. The intervention was situated within a community-based micro-enterprise context, meaning that its findings should not be interpreted as directly representative of larger enterprises, industrial circular supply chains, or communities with substantially different institutional and environmental conditions. The assessment

also primarily captures changes associated with the intervention period and therefore cannot establish the long-term durability of newly developed circular business practices, the persistence of enterprise-level income effects, or the stability of downstream markets for recovered materials and products. These boundaries suggest that the value of the present study lies principally in demonstrating an integrated community-level intervention model rather than in claiming universal causal effects across different geographical, economic, or institutional settings.

Future research should examine whether the capacities developed through participatory circular-enterprise interventions remain operational after external facilitation is withdrawn and whether they generate measurable improvements in enterprise survival, household income diversification, material recovery, and community-level environmental outcomes over longer periods. Subsequent studies could employ longitudinal designs, comparative community cases, social-network analysis, material-flow analysis, and life-cycle assessment to connect changes in entrepreneurial capability with measurable circularity and resilience outcomes. Research could also investigate how digital platforms, local procurement systems, cooperative structures, financing mechanisms, and municipal waste policies influence the scalability of community-based waste-to-value enterprises. For the general public, the study provides a practical conceptual message: community resilience can be strengthened when environmental problems are approached not only as issues requiring disposal or regulation, but also as opportunities for collective learning, responsible entrepreneurship, resource recovery, and locally generated economic value.

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