Working Paper

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From Waste to Wealth: The Role of Microfinance Institutions as a Catalyst for SME-Led Plastic Recycling in Pakistan

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List of Abbreviations:

Abbreviation	Full Form
ADB	Asian Development Bank
BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CSR	Corporate Social Responsibility
EIA	Environmental Impact Assessment
EPR	Extended Producer Responsibility
FGD	Focus Group Discussion
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
ICT	Information and Communication Technology
IGES	Institute for Global Environmental Strategies
ISO	International Organization for Standardization
KIIs	Key Informant Interviews
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory
MCI	Material Circularity Indicator
MFIs	Microfinance Institutions
MoCC&EC	Ministry of Climate Change and Environmental Coordination (Pakistan)
NAP	National Adaptation Plan
NDCs	Nationally Determined Contributions
NOC	No-Objection Certificate
NPAP	National Plastic Action Partnership
PET	Polyethylene Terephthalate
PMN	Pakistan Microfinance Network
PRO	Producer Responsibility Organization
RDF	Refuse-Derived Fuel
SDGs	Sustainable Development Goals
SDPI	Sustainable Development Policy Institute
SEZ	Special Economic Zone
SMEs	Small and Medium Enterprises
SMEDA	Small and Medium Enterprises Development Authority
SRO	Statutory Regulatory Order
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USD	United States Dollar
WEF	World Economic Forum

Executive Summary

Plastic waste mismanagement in Pakistan poses a critical environmental and economic challenge with over 2 million tons of plastic waste generated annually, of which only 8% is recycled while more than 70% remains uncollected or mismanaged. The Small and Medium Enterprises (SMEs) engaged in plastic recycling represent a high potential to address this crisis, however, their impact remains constrained by financial inaccessibility, informality and regulatory fragmentation. This working paper explores how Microfinance Institutions (MFIs) can become central enablers for supporting a more inclusive, climate-smart and efficient plastic recycling economy in Pakistan.

Drawing on primary fieldwork, data analysis, stakeholder consultations and a Life Cycle Assessment (LCA) of SME-operated plastic recycling facilities in Pakistan, the paper provides strong empirical evidence of the environmental and economic viability of SME-led plastic recycling:

- Mechanical recycling led by SMEs achieved 84% yield in plastic recovery.
- The LCA analysis results represented 70–80% lower greenhouse gas emissions compared to virgin plastic production and 30% reduction in energy costs when powered by solar.
- Water use efficiency and waste diversion from landfills also improved significantly, with landfilling shown to result in only 55% material recovery and high methane emissions.
- Closed-loop PET recycling showed the highest climate benefits, but required higher capital investments, making low-tech mechanical recycling the most viable option for SMEs when supported with MFI interventions.

A cost-benefit analysis has been conducted as part of this study which estimates that supporting approximately 200 recycling SMEs through MFI-led financial products, technical training and licensing support could generate PKR 1.1 billion in annual socio-environmental benefits. This includes savings on landfill use, import substitution for virgin plastic, emissions reduction and green job creation. This has been proved with a Benefit-Cost Ratio of 4.07, the analysis clearly demonstrates that targeted investments in recycling SMEs yield high returns for the economy and the environment alike.

However, several systemic barriers continue to hamper the progress, like the absence of a comprehensive national plastic waste management law, coupled with fragmented provincial regulations, has created administrative burdens for SMEs operating across jurisdictions. Moreover, the implementation of tools such as Extended Producer Responsibility (EPR) remains weak, with no binding mandates, monitoring systems or financing pathways for plastic producers and linked SMEs. Also, the informal recyclers who manage almost 60–80% of plastic waste are excluded from partial EPR programs or waste related fragmented policies, cooperative structures, and financial services. Additionally, despite the central role of women in waste picking and informal recycling, gender-blind policies have kept them out of financing channels. The lack of performance-based tools such as LCA for SME financing and green finance access further impedes transparency and eligibility for climate funds.

To address these challenges and unlock the untapped potential of recycling SMEs, this working paper proposes a set of evidence-based policy recommendations:

- **Formalize and license recycling SMEs** through a unified national registration and compliance framework to enable access to finance and government support.
- **Mandate Extended Producer Responsibility (EPR)** through legally binding national regulations, with a portion of EPR funds allocated to SME development and cooperative integration.
- **Expand access to green microfinance** by enabling MFIs to offer tailored financial products for recycling SMEs, supported by climate finance instruments and fiscal incentives.
- **Institutionalize Life Cycle Assessment (LCA)** as a prerequisite for SME lending, enabling climate-smart financing and performance-based evaluations.
- **Support gender-inclusive recycling models** by designing women-targeted microfinance products and cooperative support mechanisms.
- **Develop digital waste traceability systems** integrated with EPR reporting and SME licensing to enhance monitoring, transparency, and access to high-value supply chains.
- **Establish green innovation hubs and incubation centres in the Special Economic Zones (SEZs)** to support SME-led recycling technology development, product diversification, and market linkages.

The findings of this working paper demonstrate that with strategic policy reform, inclusive financing, and performance-based tools like LCA, Pakistan's plastic recycling sector can move from fragmentation to formalization, and from environmental liability to economic opportunity. MFIs are uniquely positioned to catalyse this shift, enabling recycling SMEs to become key actors in Pakistan's transition to a climate-resilient, circular economy.

Acknowledgment

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We are deeply thankful to the **SME plastic recycling operators** in Karachi, Hyderabad, Peshawar, Rawalpindi and other cities who generously participated in our fieldwork and **Key Informant Interviews (KIIs)**. Their openness in sharing operational data, challenges, and insights played a critical role in the development of the LCA and the overall findings of this study.

We also acknowledge the consistent support received from **Microfinance Institutions (MFIs)** including **Kashf Foundation, NRSP, Akhuwat**, and the **Pakistan Microfinance Network (PMN)** for engaging with the study, sharing their experiences, and contributing to discussions on the role of inclusive finance in the plastic recycling ecosystem.

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Introduction

Plastic waste management has emerged as a critical environmental challenge globally, with developing countries like Pakistan facing severe consequences due to inadequate recycling infrastructure and limited regulatory enforcement. The growing demand for plastic in industrial and consumer sectors has led to an exponential increase in waste generation, much of which ends up in landfills, rivers, and oceans, exacerbating pollution and ecological degradation. In this context, Small and Medium Enterprises (SMEs) engaged in plastic recycling play a pivotal role in mitigating environmental harm and promoting sustainable waste management. However, financial constraints and limited access to credit often hinder their growth and efficiency. Microfinance institutions (MFIs) can serve as a crucial enabler by providing SMEs with financial resources, technical support, and capacity-building initiatives, fostering a more structured and efficient plastic recycling industry (Khalid, 2024).

Plastic pollution is a significant environmental challenge in Pakistan, exacerbated by rapid urbanization, population growth and inadequate waste management infrastructure. While the country generates millions of tons of plastic waste annually, only a small portion is effectively recycled. The lack of proper disposal and recycling systems leads to severe environmental consequences including pollution of water bodies, soil degradation, and increased greenhouse gas emissions (Hashmi, et al., 2023). To address this emanating issue, it requires a multi-stakeholder approach, with SMEs playing a pivotal role in developing innovative recycling solutions.

SMEs engaged in plastic recycling operate in a challenging economic situation, where access to capital remains a primary constraint. Traditional financial institutions often view recycling businesses as high-risk ventures due to market volatility and uncertain returns. This has led to limited investment in recycling technologies and facilities, hindering the sector's growth. In this context, MFIs can serve as a vital financial intermediary by offering tailored loan products, flexible repayment structures, and technical support to recycling enterprises (Nuruzzaman, et al., 2025).

Furthermore, the formalization of the recycling sector is necessary to attract larger investments and create sustainable business models. Many recycling SMEs operate informally, limiting their ability to access financing, government incentives, and market linkages. Therefore, strengthening regulatory frameworks and encouraging financial inclusion through MFIs can help integrate these enterprises into the mainstream economy, thereby enhancing their contribution to plastic waste management and environmental sustainability.

Pakistan Specific Context:

The SwitchAsia (2025) report "Plastic Policies in Pakistan (Country Profile)" presented concerning statistics which showed the extent of plastic pollution in the region. The total plastic waste output in Pakistan reaches 2 million tons yearly and the country fails to properly manage 86% of this waste which results in severe environmental deterioration and health issues. While previous estimates suggested that the Indus River carries large amounts of plastic waste to the Arabian Sea, recent research indicates that the

contribution of big rivers like the Indus to marine plastic pollution has been overestimated. However, the Indus remains one of the most plastic-polluted rivers globally, with significant plastic accumulation along its banks (World Bank, 2022). Despite these challenges, only about 8% of plastic waste in Pakistan is recycled, highlighting the urgent need for improved waste management strategies and circular economy initiatives.

Pakistan faces significant deficiencies between its plastic waste management framework and its execution methods in current times. The collection rate of municipal waste stands at around 50% while low recycling activity occurs because of improper waste sorting and insufficient waste management facilities. The provincial plastic bans established by Sindh in 2006 and Punjab in 2024 show inconsistent execution because they both contain varying restrictions. The 2023 Single-Use Plastics Prohibition Regulations try to achieve national alignment by prohibiting these items but encounter resistance from industry groups and no suitable replacement options exist. Research indicates that the plastic waste market within Pakistan accounts for USD 1.2 billion however SMEs only exploit 15% of this value while facing various challenges (Azad 2024).

SMEs are central to Pakistan's economic framework. As defined by the Small and Medium Enterprises Development Authority (SMEDA), SMEs in Pakistan are businesses with up to 250 employees and annual turnover below PKR 800 million. According to the Economic Survey 2024–25, SMEs account for nearly 90% of all business establishments, contribute 40% of GDP, and provide employment to around 80% of the non-agricultural labour force. In the fiscal year 2024–25, small-scale manufacturing primarily driven by SMEs, grew by 9.08%, helping maintain a modest 2.42% industrial sector growth. These enterprises are critical for job creation, supply chain resilience, and innovation across traditional and emerging sectors, including green industries and recycling.

Within this economic landscape, SMEs engaged in plastic recycling have emerged as vital yet underutilized actors in Pakistan's sustainability transition. SDPI's fieldwork and consultations identified numerous active plastic recycling SMEs operating in urban hubs such as Karachi, Lahore, Faisalabad, Hyderabad, and Rawalpindi. These enterprises, often informal, achieve recycling efficiency rates of up to 84%, revealing strong technical capacity despite operating without policy recognition or consistent financial support. When strategically supported—through microfinance, technical training, and regulatory measures like Extended Producer Responsibility (EPR) and Life Cycle Assessment (LCA)—these SMEs can play a transformative role in reducing plastic leakage, lowering emissions, and strengthening the circular economy. However, access to credit, lack of licensing, and informal labour structures continue to constrain their potential. Addressing these gaps by formalizing SMEs, aligning financial tools, and mandating ecological performance metrics will be essential to unlock the sector's full contribution to national climate and development goals.

The Microfinance Institutions (MFIs) are financial entities that provide small-scale loans, savings, insurance, and other financial services to low-income individuals or enterprises typically excluded from the formal banking system. In Pakistan, MFIs play a critical role in promoting financial inclusion, poverty alleviation, and entrepreneurship, especially for women and microenterprises. According to the Pakistan Microfinance Network (PMN) Annual Report 2023, over 9 million active borrowers were served by MFIs nationwide, with

a gross loan portfolio exceeding PKR 380 billion[1]. The significance of MFIs in Pakistan extends beyond basic financial services—they act as enablers of economic empowerment by offering collateral-free credit, flexible repayment options, and community-based lending models. This is particularly impactful in underserved sectors like waste management and informal recycling, where traditional banks often deem investments too risky. MFIs such as **Akhuwat** and **Kashf Foundation** have demonstrated success in reaching marginalized groups and supporting small businesses with tailored financing models, thereby contributing to inclusive economic development and social stability

Literature Review

Umer and Abid, (2017) examined the plastic industry's economic and production practices in Pakistan, considering global trends and the growing demand for plastic. Based on extensive surveys from six industrial estates, the research analyzes raw material sources, manufacturing practices, product distribution, plastic waste management, and recycling efforts. The findings reveal that Pakistan's plastic industry largely follows a linear economy model, emphasizing the need for broader adoption of circular economy practices to enhance sustainability and waste management. Kasi, et al., (2019) investigated the environmental sustainability practices of SMEs in Pakistan, focusing on waste reduction, energy conservation, and water management. Using a qualitative approach with semi-structured interviews from 30 manufacturing SMEs, the research highlights the challenges faced by firms due to energy shortages and water scarcity. The findings reveal that while medium-sized firms adopt some sustainability measures, such as air pollution control and wastewater recycling, small firms show limited engagement, indicating a need for stronger policies to promote environmental sustainability.

Shah, et al., (2019) examined the role of local NGOs in enhancing rural livelihoods in northern Pakistan through microfinance initiatives. Using Structural Equation Modeling (SEM) and survey data from 566 respondents, the research evaluates the impact of microfinance projects on income, consumption, empowerment, and employment. The findings suggest that increasing loan sizes and integrating training programs in education, health, and entrepreneurship can enhance the effectiveness of microfinance in improving welfare. Idress, et al., (2022) explored the moderating role of microfinance in the relationship between access to finance and SME growth in Karachi, Pakistan. Using survey data from 250 SMEs and applying descriptive and regression analysis through SPSS, the study examines financial accessibility, microfinance literacy, and SME progress based on offerings and resources. The findings confirm that microfinance significantly enhances SME growth by improving access to finance, suggesting that targeted financial support and literacy programs can strengthen business development.

Recently, Farooq and Naeem, (2025) examined the role of microfinance institutions (MFIs) in providing climate risk insurance, using a mixed-methods approach that combines quantitative financial data and qualitative case studies from the UK, Italy, India, and Bangladesh. The findings indicate that MFIs play a crucial role in offering climate risk

[1] **Pakistan Microfinance Network (PMN). (2024).** *Annual Report 2023*. Pakistan Microfinance Network. Available at: https://pmic.pk/wp-content/uploads/2024/06/02-final-annual-report-2023-4.pdf

insurance to vulnerable populations, but their effectiveness varies due to regulatory and financial constraints. While MFIs in developed countries benefit from structured financial environments, those in developing nations face challenges such as resource limitations and low financial literacy.

Methodology

This policy brief is grounded in a multi-method research framework that combines fieldwork, stakeholder consultation, key informant interviews (KIIs), and life cycle impact assessment (LCA) to provide a comprehensive understanding of the role of Microfinance Institutions (MFIs) in supporting SMEs engaged in plastic recycling in Pakistan.

1. **Literature Review:** The methodology included a comprehensive review of global best practices, national policy frameworks, and academic and grey literature. Documents reviewed included the 2023 Single-Use Plastics Prohibition Regulations, EU SwitchAsia's "Plastic Policies in Pakistan", "National Plastic Action Partnership (NPAP)" "Punjab Plastic Waste Strategy" other SROs and regulations on bans on single use plastics and studies on the circular economy and microfinance's role in SME development. This helped contextualize findings within broader policy trends and sustainability objectives.
2. **Field Visits and Key Informant Interviews (KIIs):** The research team from SDPI conducted in-depth field visits to a diverse set of recycling SMEs operating in Karachi, including Davaam Life, Green Earth Recycling, Concept Loop, Zephyr Waste Solutions, and others. These visits enabled direct observation of operational challenges, financial constraints, and innovation potential. Structured KIIs were conducted with SME founders, operational managers, and technical experts to gather qualitative insights on financing needs, technological barriers, and regulatory hurdles. The KIIs survey included information on how much plastic waste do they handle, mode of recycling, imported plastic, consumer base, type of plastic, operations related details, workforce related details, engagement with informal sector for segregation purpose, financial models, hurdles and gaps, potential for scalability.
3. **Stakeholder Consultation:** A high-level multi-stakeholder consultation was held on March 13, 2025, bringing together representatives from the public and private sectors, microfinance institutions (e.g., Akhuwat, Kashf Foundation), large corporations (e.g., Unilever), development partners, and informal sector representatives. The session focused on identifying enabling mechanisms for scaling plastic recycling through microfinance, while promoting gender inclusion, financial innovation, and regulatory reform. Insights from this dialogue were instrumental in shaping policy recommendations.
4. **Life Cycle Impact Assessment (LCA):** To quantify the environmental and economic viability of SME-led recycling, a comparative Life Cycle Assessment (LCA) was conducted. Data was collected from six SMEs on key performance indicators, including greenhouse gas emissions, energy consumption, recycling yield, and waste reduction. This primary data was complemented with secondary data from global LCA literature to benchmark Pakistani practices. The assessment compared low-tech mechanical recycling with other methods such as incineration, pyrolysis, and closed-loop recycling to evaluate their carbon footprints and circularity metrics.
5. **Cost-Benefit Analysis (CBA):** To quantify the potential socio-economic and environmental benefits of scaling up plastic recycling through microfinance-supported SMEs, a **Cost-Benefit Analysis (CBA)** was conducted as part of this study. The objective was to evaluate the viability of targeted investments by

Microfinance Institutions (MFIs) in enabling 200 plastic recycling SMEs across urban centres in Pakistan, particularly those engaged in low-tech mechanical recycling. The analysis considered both direct and indirect benefits arising from SME operations, including savings in landfill usage, reductions in greenhouse gas (GHG) emissions, energy cost savings through solar adoption, avoided costs of virgin plastic imports, public health benefits from reduced environmental pollution, and income generation through green job creation. These benefits were monetized using conservative market estimates and primary data obtained during fieldwork, supplemented by values from relevant national and international studies. On the cost side, the model factored in key expenditures such as technical training, infrastructure development, machinery depreciation, licensing and compliance requirements, and loan servicing costs associated with microfinance administration. Assumptions were based on current market conditions, expert consultations, and field-level insights from SME operators in Karachi.

6. **Triangulation and Synthesis:** Findings from fieldwork, stakeholder consultations, and LCA were triangulated to ensure robustness. This triangulation helped validate the observed challenges and highlight actionable insights for financial inclusion, regulatory improvement, and technological advancement in the plastic recycling sector.

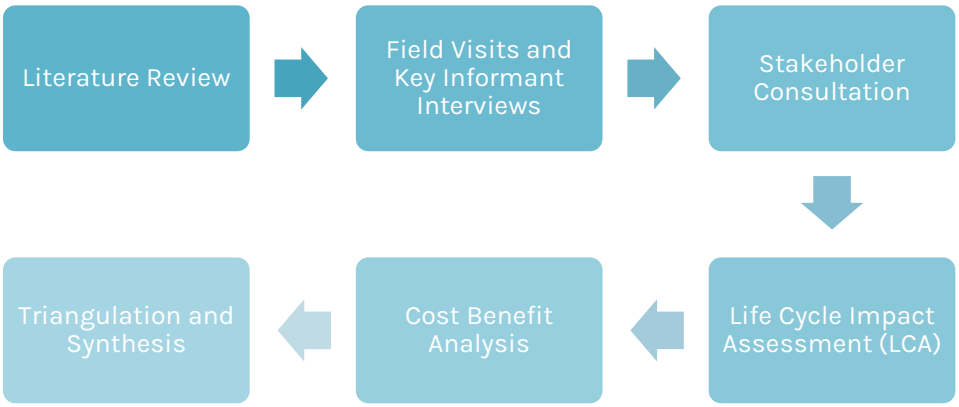


Figure 1: Methodology Steps.

Discussion and Analysis:

Plastic Recycling Potential:

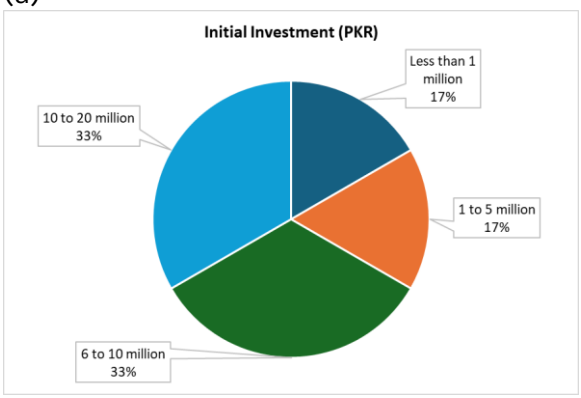
Based on evidence generated by SDPI's research and LCA, Pakistan holds the potential to recycle up to 25–30% of its total annual plastic waste, a significant increase from the current national recycling rate of approximately 8%. This potential is rooted in the capacities of recycling industry including the active Small and Medium Enterprises (SMEs) operating in major cities including Karachi, Lahore, Faisalabad, Hyderabad and Rawalpindi. These SMEs, when supported with microfinance, low-tech mechanical recycling equipment, and access to formal waste supply chains, demonstrate high efficiency in producing recycled plastic outputs with up to 84% recovery rates.

SDPI's findings also indicate that if extended producer responsibility (EPR) compliance and **mandatory Life Cycle Assessment (LCA)** reporting are institutionalized, SMEs can consistently maintain environmental performance and ensure traceability in plastic flows. Moreover, microfinance-facilitated expansion could double the sector's capacity, reduce greenhouse gas emissions by up to 70%, and create significant employment opportunities. Thus, with enabling policies and financial inclusion, Pakistan can substantially scale up its recycling capacity—transforming its plastic waste challenge into an opportunity for circular economy development.

Financial Barriers Faced by Recycling SMEs

The growth constraints of plastic recycling businesses in Pakistan exist because of their significant financial investment requirements. The high initial investment needed to buy machinery like shredders, granulators and extruders, amounts to PKR 1-20 million (Figure -a). The costs associated with operational expenses, raw material procurement (PKR 30–350 per kilogram) and employee compensation as well as utility bills amount to monthly expenses of PKR 0.5 to 5 million (Figure -b, c). The financial requirements of SMEs become even more demanding because formal banking institutions provide loans exclusively to only 12% of businesses interviewed based on field visits within Karachi. Traditional banks showed reluctance to provide credit due to their strict collateral demands and risk avoidance approach which led to unavailable credit especially for SMEs.[2]

(a)



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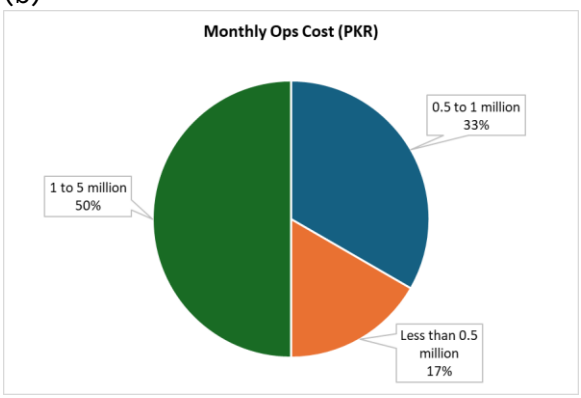

[2] Insights collected during field visits to Karachi.

(c)

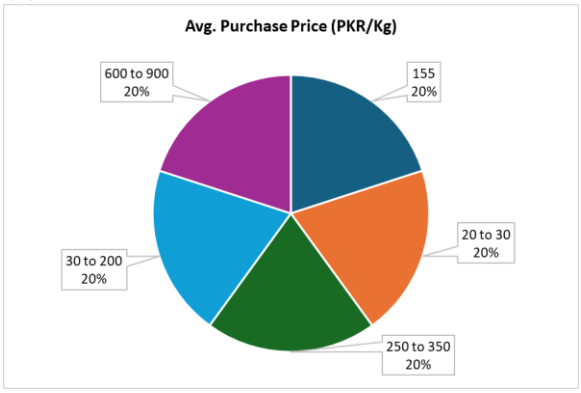

Figure 2: Key Financial Metrics in Plastic Recycling Operations

Economic Viability and Market Limitations

The existing economic challenges to recycling operations stem from market-related obstacles which create barriers to profitability. The competition between recycled plastic products and inexpensive virgin plastic materials creates worrisome conditions for SMEs because it causes their profit margins to decline by 15–20% (Figure). The control informal waste collectors maintain over refuse collection disrupts the entire process of manufacturing recycled products starting from waste feedstock acquisition. The control of plastic waste by informal waste collectors results in unreliable supply of good quality plastic materials for SMEs and prevents them from securing reasonable prices for materials. The market is creating new opportunities yet to be exploited. SMEs can expand their business through recycled PET flakes industry growth along with Punjab Plastic Road Program support to gain new sources of income.[3]

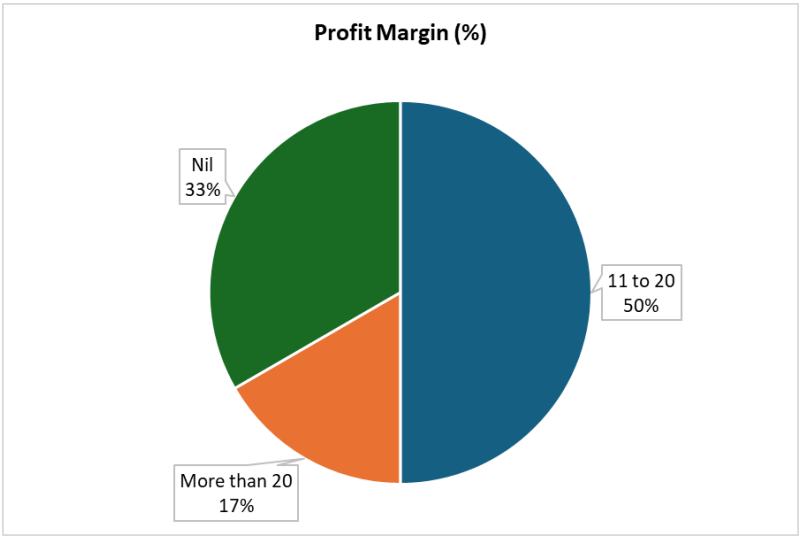

Figure 3: Profit margins by plastic recycling SMEs

Role of Life Cycle Assessment (LCA) Tool:

According to United Nations Environment Programme (UNEP), the Life Cycle Impact Assessment (LCA) is an internationally recognized analytical tool used to evaluate the environmental impacts of a product, process, or service throughout its entire life cycle. This includes all stages — from the extraction of raw materials (cradle), through manufacturing and use, to disposal or recycling (grave or cradle-to-cradle)[4]. The LCA process is guided by standardized frameworks such as ISO 14040 and 14044, and typically consists of four key phases:

- **Goal and Scope Definition**: Establishes the purpose, boundaries, and level of detail of the study (e.g., comparing mechanical vs. chemical recycling processes).
- **Life Cycle Inventory (LCI)**: Gathers quantitative data on energy use, raw material inputs, emissions, water consumption, and waste generation at each stage.
- **Life Cycle Impact Assessment (LCIA)**: Translates the inventory data into environmental impact categories, such as:
  - Global warming potential (GHG emissions)
  - Water and energy use
  - Eutrophication and acidification
  - Human and ecosystem toxicity
  - Resource depletion
- **Interpretation**: Synthesizes findings to identify improvement areas, support decision-making, and ensure data robustness.

LCA goes beyond traditional performance metrics by providing **system-wide visibility** into the environmental burden of a process or material. In plastic recycling, for instance, LCA allows for comparison between various methods (e.g., mechanical recycling vs. incineration vs. landfill) in terms of energy efficiency, carbon emissions, and circularity outcomes.

In the Pakistani context, where data on recycling technologies, environmental baselines, and waste streams is scarce, LCA serves a dual role — it acts as both a **diagnostic tool** for identifying environmental hotspots and an **accountability tool** for proving the effectiveness of sustainability interventions.

Environmental and Economic Case for SME-Led Recycling

LCA assessment demonstrated strong evidence on how Pakistani SME-led plastic recycling operations create environmental benefits together with economic advantages. These insights can not only strengthen the case for targeted microfinance interventions but also highlight the need for supportive policies that align with sustainability goals. Studies have shown that mechanical recycling activities of SMEs prove effective in minimizing plastic waste pollution of the environment. The process of processing used plastics using mechanical methods produces lower greenhouse gas emissions of 70-80% than producing new plastic from scratch (Alhazmi et al., 2021). PET recycling cycles implemented through

[4] **United Nations Environment Programme (UNEP). (no date).** *Life Cycle Initiative*. UNEP. Available at: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/life-cycle-initiative

closed-loop systems generated climate-negative outcomes since they replaced PET production methods that require high amounts of energy (Schwarz et al., 2021).

The emissions from incineration processes reach 150% above baseline levels because the energy recovery system cannot completely settle grid electricity requirements (Alhazmi et al., 2021). The energy consumption for mechanical recycling ranges from 110 to 200 kWh per ton with levels that significantly surpass the 400+ kWh needed for pyrolysis according to Vlasopoulos et al. (2023). Operating SMEs with solar power capabilities reduce their energy expenses during operations by thirty percent[5]. Moreover, recycling conserves water by eliminating the need for resource-intensive virgin plastic production yet landfill operations worsen water scarcity and environmental damage. Experienced operators of low-tech mechanical recyclers currently produce 84% recyclable materials, but this rate can be enhanced with improvements in sorting technology which reduces the non-recyclable residue to 16%. Most plastic waste processing through landfill operations fails to treat an effective 55% of plastic affecting long-term environmental harm (Alhazmi et al., 2021).

Table 1 contains a comparative evaluation of plastic waste management approaches derived from an LCA research conducted by SDPI. Research data was obtained from six SMEs in Pakistan and secondary data sources from established research literature for the LCA analysis. The table assesses four waste disposal methods including low-tech mechanical recycling and high-tech open-loop and closed-loop PET recycling together with landfilling and incineration according to environmental performance and carbon footprint and energy consumption and waste reduction efficiency.

[5] Ibid.

Table 1: Comparative Life Cycle Assessment of Plastic Waste Management Technologies with SME Feasibility

Criteria	Low-Tech Mechanical Recycling (Pakistan SMEs)	High-Tech/Open-Loop Recycling	Closed-Loop Recycling (e.g., PET)	Tertiary Recycling (Pyrolysis, Gasification)	Incineration with Energy Recovery	Landfilling	Refuse-Derived Fuel (RDF)
Environmental Impact	Net negative impact; 84% yield reduces virgin plastic need; positive for climate, health, ecosystems	Greater environmental benefits than low-tech; better recyclate, but higher energy and resource use	Highest environmental benefit (net negative); offsets virgin PET production; quality recyclate	High GHGs and energy use; requires improvements to reduce emissions	Highest CO_2 and toxic byproducts; reduces landfill use but harms health & environment	High methane & leachate production; least sustainable option	Some climate benefit (net negative); offsets fossil fuel combustion
Carbon Footprint	Lower due to avoided virgin plastic; 1.4–2.0 kg CO_2-eq/tonne	Higher due to energy use but better substitution of virgin plastic	Net negative; highest climate benefit; displaces large volumes of virgin plastic	Emissions vary; pyrolysis reduces CO_2 by 80% for PS, gasification yields low CO_2 syngas	7.3 kg CO_2-eq/tonne; emissions not offset by energy recovery	5.3 kg CO_2-eq/tonne; significant methane emissions	Net negative; displaces fossil fuels, better than incineration
Energy Use	~50% of climate impact from electricity/fuel; more efficient than advanced methods	Higher energy demand; 66% of climate impact from energy use	110–200 kWh/tonne; 52% of impact from energy; more energy-intensive but efficient	Pyrolysis: ~400 kWh/tonne; gasification: high temp, energy-intensive	High energy recovery, but overall inefficient	Minimal energy recovery; inefficient and polluting	Moderate; depends on RDF quality and combustion efficiency
Waste Reduction/Yield	84% yield; 16% discarded; affected by input quality	Higher yield and recyclate quality; >90% achievable with sorting	High-quality output; efficient for clean, single-polymer streams	~85% yield; losses due to impurities	Reduces physical waste but adds toxic emissions	~55% material recovery; high waste and pollution	Medium; partial substitution for fossil fuel use
Water Use	Requires cleaning water; net savings due to avoided virgin plastic	Higher water use but similar net savings	More water-intensive, but offsets virgin PET water use	Depends on cooling and processing needs	Adds to water contamination through residues	Moderate water impact; leachate risk	Moderate water use in pre-treatment
Sustainable Practices	Energy-efficient for SMEs; switch to renewables recommended; reduced inputs improve yield	Scope for mechanization & renewable energy use; better sorting & input quality key	Promotes circular economy; high MCI (~90%); best when clean feedstock available	Needs optimization to reduce emissions and energy use; viable for polyolefins	Unsustainable; toxic emissions; poor fit for circular economy	Poor waste containment and circularity; highest leakage risk	More sustainable than landfilling, but requires emissions control
Circularity (MCI)	~90% of max achievable; good plastic containment	High circularity; system expansion credits benefit overall impact	Highest circularity; 0% leakage; strong alignment with circular economy	Moderate; not all outputs re-enter material loops	Very low; energy recovery only, no material loop	Lowest; high leakage, low material recovery	Medium; energy loop but not material loop

Institutionalizing LCA for Climate-Smart Microfinance

Microfinance Institutions (MFIs) can play a catalytic role in scaling the plastic recycling sector by financing SMEs and informal actors. However, without proper tools for **screening, monitoring, and evaluating impact**, MFIs risk financing low-performing or environmentally harmful practices. This is where LCA becomes an essential instrument. For Pakistan to successfully scale its plastic recycling sector while meeting environmental targets, integrating Life Cycle Impact Assessment into SME financing models is essential. MFIs can lead this transformation by adopting LCA-informed credit products, collaborating with technical partners for data collection, and using LCA metrics to unlock climate finance. At a time when green finance is gaining global momentum, equipping MFIs with LCA tools will not only improve financing decisions but also anchor Pakistan's recycling economy in transparency, accountability, and climate ambition.

1. Risk Management and Investment Quality

By using LCA data, MFIs can prioritize support for SMEs that:

- Reduce greenhouse gas emissions by significant margins (e.g., 70–80% via mechanical recycling)
- Minimize energy use and operational inefficiencies
- Avoid environmentally harmful alternatives such as landfilling and incineration

This risk-based lens helps MFIs maintain **environmental integrity in their portfolios**, a key requirement for green finance accreditation.

2. Eligibility and Impact-Based Lending

MFIs can incorporate LCA-derived metrics into their credit risk assessments and design **performance-linked financial products**, such as:

- Tiered interest rates based on GHG savings per ton of recycled plastic
- Results-based financing for SMEs with >80% recycling yield or circularity scores
- Loan grace periods for businesses investing in LCA-based innovation or reporting systems

Such instruments align with **climate-smart finance models**, allowing MFIs to access concessional funds from international donors and climate finance mechanisms.

3. Compliance and Green Finance Access

Increasingly, climate finance institutions — such as the Green Climate Fund (GCF), Adaptation Fund, and international development banks — require proof of climate and environmental benefits. LCA provides the evidence base needed for:

- **Impact reporting** aligned with SDGs and NDCs
- **Due diligence** in project proposal evaluation
- Justifying subsidy or blended finance to de-risk recycling SMEs

MFIs that adopt LCA-integrated screening processes position themselves as **credible intermediaries** for green finance flows.

4. Enabling a Circular Economy

LCA can also help MFIs support a broader shift toward circularity by identifying SMEs that:

- Engage in **closed-loop recycling** (e.g., PET bottle-to-bottle)
- Reduce resource use and dependency on virgin materials
- Improve waste traceability and transparency through **data-driven operations**

By tracking and validating environmental benefits through LCA, MFIs can create a **green SME pipeline** that attracts impact investors and scales sustainable practices across Pakistan.

Insights from the High-Level Consultation

Pakistan's plastic recycling sector remains largely informal, posing significant environmental and economic challenges. The consultation highlighted that a substantial portion of recycling activities are conducted without regulatory oversight, leading to health hazards and inefficiencies in waste management. Experts emphasized that the lack of clear policies and weak enforcement mechanisms further exacerbate the problem, making it difficult to ensure sustainable recycling practices. Financial constraints were identified as a major barrier for SMEs in the sector, as traditional banks perceive recycling businesses as high-risk ventures, limiting their access to credit. As a result, many recycling SMEs struggle to scale their operations and invest in modern recycling technologies.

Addressing Gender Gaps in the Informal Recycling Economy

A key theme that emerged during the consultation was the role of gender in plastic recycling. It was noted that women, particularly in rural areas, play a significant role in informal recycling activities but face barriers such as mobility constraints, lack of access to capital, and unsafe working conditions. Experts from the Kashf Foundation highlighted the need for gender-inclusive financial policies that provide women entrepreneurs with targeted loans, business training, and cooperative strengthening programs. Promoting financial inclusion for women in the recycling sector could significantly enhance its efficiency and inclusivity.

Corporate Partnerships and Supply Chain Integration

Corporate engagement was another major discussion point. Representatives from Unilever and other industry players highlighted their efforts to integrate recycled plastics into supply chains but pointed out that sourcing high-quality recycled material remains a challenge. The consultation emphasized that stronger collaborations between private corporations, SMEs, and MFIs could help address this issue by improving the availability of quality recycled plastics and fostering investment in recycling technologies. Additionally, regulatory misalignment across provinces and inadequate fiscal incentives for private-sector participation were identified as major hurdles to scaling sustainable recycling solutions.

Global Innovations in Plastic Waste Management

Global best practices were also explored during the discussion, with experts presenting successful waste management models from other countries. Case studies such as Rubicon, a digital waste management platform, and TerraCycle, a company specializing in recycling non-recyclable waste, were cited as innovative examples of how technology can enhance recycling efficiency. The discussion also emphasized the need for Extended Producer Responsibility (EPR) policies in Pakistan, which would require manufacturers to take responsibility for their plastic waste, thereby creating funding opportunities for SMEs engaged in recycling.

Expanding the Role of Microfinance Institutions (MFIs)

During consultation and FGDs, the Microfinance institutions (MFIs) were recognized as crucial enablers in bridging the financing gap faced by SMEs. Unlike traditional banks, MFIs are designed to support small-scale enterprises through **tailored loan products, flexible collateral-free mechanisms, and community-based lending models**. These instruments are particularly effective for recycling businesses, which often operate in informal settings and are unable to meet the documentation or asset requirements of commercial banks.

Beyond financial products such as low-interest loans, MFIs can offer **technical and entrepreneurial support**, including financial literacy training, assistance in preparing business plans, support in acquiring licenses and permits, and help in establishing formal credit histories. These services not only improve the financial viability of SMEs but also contribute to their **formalization and integration into the regulated economy**—a critical step in expanding their reach and impact.

Field visits conducted by SDPI in Karachi highlighted this potential. For instance, **Davaam Life**, supported by USD 1.8 million in funding, successfully scaled its refill stations, cutting plastic packaging expenses by 35–40%. Similarly, **Savvy Engineers** secured PKR 7.99 million from the **HEC Innovator Seed Fund** to develop 3D printing filaments from recycled plastics. These cases demonstrate that access to structured finance combined with technical mentorship enables significant innovation and impact in the recycling sector.

MFIs can also act as intermediaries to help recycling SMEs **access global green finance mechanisms**, such as the **Green Climate Fund (GCF)** or **UNDP's Climate Finance Accelerator**, thereby unlocking larger pools of concessional capital. Moreover, by leveraging gender-inclusive lending models—as practiced by institutions like **Akhuwat** and **Kashf Foundation**—MFIs can increase women's participation in the recycling economy, expanding the sector's social and environmental footprint.

In summary, scaling up plastic recycling in Pakistan is contingent upon enabling financial mechanisms that are inclusive, low-cost, and tailored to the SME context. MFIs are uniquely positioned to fill this gap and catalyse the growth of a more efficient, formal, and impactful recycling ecosystem across the country

Cost-Benefit Analysis (CBA)

To quantify the economic and environmental viability of supporting plastic recycling SMEs in Pakistan, a CBA was also conducted to assess future projection based on the projection if support by MFIs is provided to approximately 200 small and medium enterprises across multiple cities in future, especially those SMEs involved in plastic recycling. This analysis evaluates the impact of microfinance support—including affordable loans, technical assistance, and capacity-building—on the economic performance and sustainability outcomes of these enterprises.

Assumptions:

- **Target SMEs**: 200 engaged in mechanical plastic recycling
- **Support Mechanism**: Microfinance loans, technical training, infrastructure support, and regulatory facilitation
- **Currency Rate**: 1 USD = PKR 280 (approx.)

Table 2: Annual Benefits per SME (PKR)

Benefit Category	Estimated Value PKR
Waste management and landfill savings	1,500,000
Energy cost reduction (solar, efficient tech)	800,000
Avoided virgin plastic import costs	1,200,000
Monetized GHG emission reductions	600,000
Health cost savings from reduced pollution	400,000
Job creation and income generation	1,000,000
Total Annual Benefit per SME	5,500,000

Table 3: Annual Costs per SME (PKR)

Cost Category	Estimated Value PKR
Technical training and support	300,000
Infrastructure and equipment (depreciated)	800,000
Regulatory compliance and licensing	150,000
Loan servicing and administration	100,000
Total Annual Cost per SME	1,350,000

Table 4: Aggregated Results for 200 SMEs

Metric	Value (PKR)
Total Annual Benefit	1.1 billion
Total Annual Cost	270 million
Net Annual Benefit	830 million
Benefit-Cost Ratio (BCR)	4.07

Interpretation

- A **Benefit-Cost Ratio of 4.07** indicates that for every PKR 1 spent, the economy gains PKR 4.07 in return.
- Supporting 200 recycling SMEs through microfinance institution mechanisms can generate substantial socio-economic and environmental returns.
- This model promotes green jobs, reduces plastic pollution, conserves energy, and aligns with Pakistan's broader sustainability and climate targets.

Policy and Regulatory Gaps

Despite growing awareness and momentum for sustainable plastic waste management, Pakistan's regulatory and policy landscape remains fragmented, inconsistent, and under-enforced—creating significant bottlenecks for the growth of recycling SMEs and the integration of microfinance mechanisms.

1. Absence of a National Framework on Plastic Waste Management

Pakistan currently lacks a comprehensive National Plastic Waste Management Law that provides a clear roadmap for collection, recycling, disposal, and market integration of recycled products. While the 2023 Single-Use Plastics Prohibition Regulations have attempted to harmonize some federal-level bans, enforcement is inconsistent and often resisted by industry players due to lack of affordable alternatives. The absence of national legislation undermines coordinated efforts and limits investor confidence in the recycling sector.

2. Inadequate Implementation of Extended Producer Responsibility (EPR)

Although EPR has been introduced through various provincial efforts and proposed under national guidelines, mandatory implementation, legal enforcement, and fiscal mechanisms to operationalize EPR remain weak. There is no standardized system in place to monitor or hold producers accountable for post-consumer plastic waste. This leaves SMEs without predictable sources of plastic waste feedstock or co-financing mechanisms that could emerge from a robust PRO (Producer Responsibility Organization) ecosystem. Moreover, EPR compliance is not currently linked with SME incentives, which could otherwise support their inclusion in formal supply chains.

3. Fragmented Provincial Policies and Licensing Barriers

Plastic bag bans, recycling standards, and licensing requirements vary drastically across provinces—Sindh's 2006 plastic ban, Punjab's 2024 regulations, and KP's informal sorting systems each operate in silos. SMEs operating across multiple cities must comply with different regulatory interpretations and approvals, creating administrative burden and limiting formal expansion. Additionally, many SMEs are unable to access basic municipal permits or environmental no-objection certificates (NOCs) due to complex documentation, lack of technical know-how, or informal status.

4. Lack of Fiscal Incentives and Recycling-Specific Financing

There are no direct fiscal incentives—such as tax rebates, subsidies, or concessional loans—for SMEs investing in recycling infrastructure or technology. This discourages long-term capital expenditure and innovation. The absence of credit enhancement schemes also prevents formal banks from de-risking recycling enterprises. Moreover, there is no dedicated climate or green SME financing window at the federal level, and existing microfinance regulations do not distinguish between sectors with environmental co-benefits and conventional business loans.

5. Disconnection between Informal and Formal Waste Economies

A significant proportion (60–80%) of plastic waste recovery in Pakistan is conducted by informal waste collectors and aggregators. However, these actors are largely excluded from formal recycling networks and SME support schemes, creating a gap in the waste value chain. Informal collectors do not benefit from EPR programs, lack health and safety protections, and are excluded from training, microcredit, and cooperative development efforts. This disconnect reduces the availability of consistent, high-quality plastic waste for SMEs and limits scale-up potential.

6. Gender-Blind Waste Sector Policies

Despite the heavy participation of women in informal waste sorting and recycling, particularly in peri-urban and rural areas, existing policy frameworks are gender-neutral and fail to account for the differentiated barriers women face—such as mobility limitations, safety risks, and lack of access to financial services. There are no specific credit products or enterprise support programs targeted at women recyclers, missing a critical opportunity for inclusive growth in the sector.

7. Gaps in Data, Monitoring, and Compliance Tools

Another major policy blind spot is the lack of data infrastructure and digital tools to monitor plastic waste generation, collection, recycling, and leakage. There is no centralized digital registry of recycling businesses, volumes processed, or compliance metrics. Furthermore, Life Cycle Assessment (LCA) reporting is not required for SMEs or industries, limiting transparency on environmental performance and hampering efforts to develop sustainability-based financing models. Without traceability and certification systems, SMEs struggle to access high-value markets or integrate with corporate EPR programs.

8. Weak Alignment with Climate and Circular Economy Goals

Despite Pakistan's commitments under the National Climate Change Policy, Nationally Determined Contributions (NDCs), and SDG targets, there is a lack of alignment between climate planning and waste sector interventions. Plastic waste recycling remains under-prioritized in national and subnational climate finance strategies. As a result, circular economy pathways that integrate recycling into low-carbon development trajectories are missing from climate investment plans and Green Climate Fund pipelines.

Policy Recommendations

Transforming Pakistan's plastic recycling sector requires a multi-pronged strategy that integrates financial inclusion, regulatory coherence, technological innovation, and inclusive governance. Based on field insights, stakeholder consultations, and cost-benefit analysis, the following policy recommendations are proposed:

1. Formalize and Strengthen the SME Recycling Ecosystem

- **Establish a national licensing and registration framework** for recycling SMEs, with simplified procedures to bring informal enterprises into the formal economy. This will improve access to financing, markets, and government support programs.
- **Harmonize environmental regulations across provinces**, especially around plastic bans, recycling standards, and licensing. Uniform regulatory frameworks will improve compliance and ease of doing business for SMEs operating in multiple jurisdictions.
- **Institutionalize cooperative models** that link informal waste workers with registered recycling SMEs. MFIs should support such cooperatives to ensure steady feedstock supply, fair wages, and improved labor conditions in the sector.

2. Enforce and Expand Extended Producer Responsibility (EPR)

- **Mandate EPR compliance through legally binding national regulations**. This should include a tiered system of responsibilities for manufacturers based on the type and volume of plastic produced.
- **Strengthen the role of Producer Responsibility Organizations (PROs)** in managing plastic waste flows, and mandate that a portion of EPR funds be allocated to support recycling SMEs through training, equipment, and infrastructure development.
- **Facilitate direct linkages between PROs, MFIs, and SMEs**, enabling recyclers to access steady waste supplies, financing, and formal markets.

3. Enhance Access to Green Finance for SMEs

- Develop SME-specific green financial products through MFIs, such as:
  - Low-interest loans tailored to recycling business models
  - Green bonds and blended finance packages
  - Results-based financing tied to recycling performance or GHG reduction
- **Introduce fiscal incentives for recycling investments**, such as tax rebates, import duty exemptions for recycling machinery, and depreciation benefits.
- **De-risk investments through public-private mechanisms**, including credit guarantees, climate finance readiness funds, and donor-backed revolving credit lines.

4. Establish Green Innovation and Incubation Hubs

- **Set up Green Incubation Centers** in major cities (e.g., Karachi, Lahore, Faisalabad) to support early-stage recycling SMEs. These centers should offer:
  - Technical training and business mentorship
  - Seed funding and product development support
  - Links to academic R&D and industry networks
- Encourage **corporate partnerships and CSR investments** in these hubs, aligning private sector sustainability targets with recycling sector development.

5. Leverage Technology and Renewable Energy

- **Promote low-tech mechanical recycling solutions** for early-stage SMEs through microfinance and training. These are cost-effective, energy-efficient, and yield high recycling rates (~84%).
- Support **adoption of medium-scale automated sorting technologies**, which can achieve up to 90% recovery efficiency with appropriate investment and training.
- **Subsidize transition to solar-powered operations**, which can reduce energy costs by up to 25% and lower carbon emissions.
- **Avoid promoting chemical recycling** for SMEs due to its high operational costs and limited environmental benefits in Pakistan's context.

6. Improve Data Infrastructure and Traceability

- **Develop a centralized digital waste tracking platform** to monitor collection, sorting, and recycling activities in real time. This should be integrated with licensing databases and EPR reporting systems.
- **Introduce blockchain-based waste certification systems** to ensure the quality, origin, and destination of recycled plastic—critical for export competitiveness and corporate compliance.
- **Mandate LCA (Life Cycle Assessment) reporting** for large recyclers and PROs to promote environmental transparency, support climate finance access, and validate the sustainability of recycling practices.

7. Promote Gender-Inclusive Recycling Models

- **Design gender-sensitive microfinance products**, including group lending for women recyclers, zero-collateral loans, and mobile-based financial access.
- Offer **business and leadership training to women in informal recycling** to improve enterprise development, safety, and voice in cooperative governance.
- Support **women-led recycling enterprises** through targeted incubation programs and inclusion in PRO and supply chain networks.

8. Institutionalize Life Cycle Impact Assessment (LCA) for Performance Monitoring and Climate Finance

- **Mandate LCA reporting** for all medium-to-large recycling SMEs, PROs, and EPR-compliant corporations to assess environmental performance, particularly greenhouse gas (GHG) reductions, energy efficiency, water use, and circularity impact.

- **Use LCA as a prerequisite for public financing and international climate funds**, including GCF and UNDP Climate Finance Accelerator. Recycling SMEs that can demonstrate net-positive environmental performance through LCA will be more competitive in accessing concessional finance.
- Develop **sector-specific LCA guidelines and templates**, tailored to Pakistan's recycling context, especially for low-tech mechanical recycling, PET closed-loop systems, and RDF (Refuse-Derived Fuel) applications.
- **Train MFIs and PROs on interpreting LCA results** to improve credit evaluations, risk assessments, and alignment with green lending criteria.
- **Encourage academic and research institutions** to offer technical assistance to SMEs in conducting LCAs and publishing credible environmental performance reports that can attract investors.

9. Establish Corporate and Municipal Recycling Targets

- Mandate that **corporations meet minimum recycled plastic usage targets**, with certifications issued by authorized PROs or government bodies.
- Require **municipalities to divert a fixed percentage of plastic waste** to certified recycling units annually and include this target in their annual performance benchmarks.

Conclusion

The plastic recycling situation in Pakistan combines major challenges with possible productive possibilities. The current rate of plastic waste recycling in Pakistan remains low so the country must deal with serious environmental conditions together with public health risks. The combination of SMEs utilizing Microfinance Institutions (MFIs) enables meaningful sustainable recycling operations through financial backing and technological implementation. The policy brief shows how MFIs act as vital connectors by giving recycling SMEs financial support that enables technology purchases and business growth to make them market competitive. It also underscores the need for robust policy frameworks, including Extended Producer Responsibility (EPR) regulations and fiscal incentives, to create an enabling environment for the sector.

The achievement of a circularity requires coalition between government bodies and private enterprises as well as Microfinance Institutions (MFIs) and informal waste workers. Pakistan can build a new plastic waste management structure by implementing the recommended strategies i.e., financial inclusion, regulatory harmonization, technological innovation and gender-inclusive policies. Through these measures the country will reduce environmental harm while creating new economic prospects to establish itself as a leading sustainable waste management destination. Stakeholders and policymakers together with financial institutions must create a resilient plastic recycling system for Pakistan to achieve its environmentally sustainable goals.

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