

Integrating the Informal Sector into Circular Economy Transitions for Carbon Mitigation in Pakistan

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ABSTRACT

Pakistan faces a growing solid waste problem, now reaching 50 million tonnes annually, requiring comprehensive legal and environmental reforms. This research assesses the significant, yet largely unquantified, carbon reduction potential of the informal recycling sector, which recovers up to 90% of urban recyclables but remains outside formal regulations. Employing a mixed-methods approach, we combine life cycle assessments (LCA) with field surveys and interviews involving over 200 informal waste workers from Karachi, Lahore, and Islamabad. By comparing legal frameworks from cooperative models in Brazil and India, our results indicate that informal recyclers reduce 0.5 to 1 tonne of CO₂e per tonne of waste processed. Incorporating this sector could help cities like Islamabad recover 26,070 tonnes of waste daily, significantly contributing to Pakistan's 17% emissions reduction goal under the NDC by 2030. Nonetheless, institutional gaps in the 2023 National Waste Management Policy and EPR schemes exclude these actors, underreporting approximately 12.29 million tonnes of CO₂e annually. We advocate for legal recognition, access to microfinance, and multi-stakeholder platforms as essential steps to align environmental policies with social equity, providing a scalable model for sustainable, low-carbon development in emerging economies.

Keywords: Informal Recycling, Carbon Mitigation, Circular Economy, Waste Management, Climate Policy Integration.

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INTRODUCTION

Pakistan's escalating solid waste crisis—characterized by an annual generation of approximately 50.79 million tonnes and an exponential growth rate exceeding 2.4%—necessitates a fundamental shift in urban environmental governance structures. In the absence of centralized

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municipal recycling infrastructures, a highly responsive, decentralized informal waste economy consists of an organic network of waste pickers, scrap dealers, and micro-recyclers who recover over 80% of marketable urban recyclables (Javed, 2022). Although this informal ecosystem significantly reduces open dumping, localized ecological hazards, and landfill methane emissions, its broader contributions are systematically overlooked within national legal and policy frameworks (Imran Mukhtar, 2022). This regulatory oversight persists despite Pakistan's deteriorating macro-climate trajectory, with total greenhouse gas emissions rising from approximately 521 million tonnes of CO₂-equivalent (MtCO_{2e}) in 2021 to 529 MtCO_{2e} in 2023. While the country accounts for less than 1% of global historical emissions, its heightened vulnerability to climate shocks renders the decarbonization of its waste sector both legally and operationally essential to fulfill its Nationally Determined Contributions (NDCs) under the Paris Agreement (Goodman, 2023). Consequently, this study explores how the integration of informal waste actors into circular economy (CE) frameworks can enhance carbon mitigation efforts while promoting socio-economic equity. On a national scale, an estimated 26,070 tonnes of valuable recyclables are discarded daily in landfills; harnessing this volume through formal integration offers a means to align environmental governance with social inclusion, thereby disrupting the traditional linear economy—based on resource extraction, consumption, and disposal—and decoupling economic development from ecological degradation (Naveen Khan, 2025).

Fundamentally, circular economy (CE) paradigms dictate a structural shift away from linear extraction toward waste prevention, systemic material recovery, and regenerative resource loops. By prioritizing landfill diversion and maximizing the substitution of primary inputs with secondary materials, CE interventions effectively mitigate fugitive biogenic methane emissions from anaerobic decomposition of solid waste. Concurrently, closed-loop recycling eliminates the substantial carbon premiums associated with upstream raw material extraction and energy-intensive manufacturing processes. The operationalisation of these principles is critical for developing economies such as Pakistan, where municipal solid waste (MSW) generation scales with rapid urbanisation and rising disposable incomes, resulting in per capita generation rates as high as 0.65 kg per day (Meraj et al., 2024). According to projections by the World Bank, Pakistan's gross MSW volume is projected to expand from approximately 42 million tonnes annually by 2030 to over 66 million tonnes by 2050. This macro-waste expansion places an acute burden on the state's climate ledger; while the agriculture, forestry, and other land-use (AFOLU) sector accounts for the largest share of national emissions at 46.8%, municipal waste management remains a critical, structurally neglected vulnerability. Currently, formal municipal systems collect barely 50% of generated waste, with the remaining fraction subjected to unregulated dumping at uncontrolled, open-air sites, resulting in significant methane fluxes and persistent contamination of critical soil and water tables.

Within this compromised regulatory matrix, the informal recycling industry operates as an uncompensated yet highly efficient environmental protection service. Informal waste actors, scrap dealers, and micro-enterprises intercept approximately 80–90% of urban recyclables—a capture rate matching regional benchmarks in India and the Philippines (Batool et al., 2008). This unauthorized labor force diverts significant volumes of plastics, paper, and metallurgy from open burning and decomposition (Zhang et al., 2025b), drastically contracting industrial primary

material demands. Yet, despite generating substantial, verifiable "avoided emissions," Pakistan completely excludes these offsets from its national greenhouse gas (GHG) inventories and Biennial Transparency Reports (BTR). Consequently, while performing essential, climate-positive public utilities, informal waste pickers endure severe structural marginalization, systematically deprived of formal statutory recognition, secure access to waste streams, institutional social protections, and occupational safety frameworks. State-level environmental governance institutions continue to misclassify these actors as unregulated, low-status informalities rather than integral agents of the green urban economy, thereby stifling the integration necessary to execute a legally sound, low-carbon just transition (Nawaz, Yousafzai, Shah, et al., 2021).

Nonetheless, they do not provide much in the way of engaging in informal recycling. Municipal rules are limiting, access to finance is scarce, and coordination between authorities is weak, which has created exclusion. This policy gap reduces the ability to recover valuable materials and fails to mitigate carbon effectively. It also ends up limiting other objectives, including equal economic development. Research on CE transitions in developing contexts continues to grow faster than it has in the past. However, only a few studies explicitly quantify or conceptualise the carbon mitigation potential of informal recycling systems. Support for cooperative models and access to suitable technology can raise recyclers' rates by increasing inclusion and recycling rates while reducing dependence on landfills and greenhouse gas emissions (Nawaz, Yousafzai, Shah, et al., 2021). This kind of inclusion can also enhance livelihoods from a social equity perspective through improved compensation, deployment safety, and market access. The purpose of this study is to develop an analytical framework to mainstream informal recycling actors in Pakistan's circular economy transition. The paper looks into the institutional, policy, and socio-economic dynamics that shape these integration outcomes and identifies governance instruments, such as legal recognition, financial incentives, and participatory mechanisms that can help align informal recycling with national carbon-mitigation strategies (Ali et al., 2026). Research on informal recycling, including its environmental value and policy options, will provide evidence-based analysis of how Pakistan could undertake climate-friendly circular reforms that integrate climate action and social inclusion in its low-carbon transition (Ezeah et al., 2013).

CONCEPTUAL AND THEORETICAL FRAMEWORK

The circular economy (CE) paradigm operates as a vital systemic mechanism that complements conventional, energy-centric climate mitigation strategies. Grounded in industrial ecology and environmental law, CE frameworks possess the analytical capacity to address the estimated 45% of global greenhouse gas (GHG) emissions originating from resource extraction, material production, and land-use activities—sectors largely insulated from renewable energy transitions. Conceptually, this framework mitigates anthropogenic climate forcing through a three-tiered systemic architecture consisting of upstream prevention to eliminate waste and industrial pollution at the design stage, midstream material retention to preserve embodied energy through closed-loop recycling, and downstream regeneration to enhance biogenic carbon sequestration capacity (Haider et al., 2026).

In rapidly urbanising developing economies such as Pakistan, this theoretical transition is severely disrupted by institutional anomalies. While the state generates approximately 50 million tonnes of solid waste annually, formal municipal infrastructure achieves a recycling rate of less than 10%, highlighting a severe structural decoupling between municipal enforcement and the retention of circular materials. To operationalize CE principles under such governance deficits, regulatory instruments must look beyond superficial mandates—such as isolated single-use plastic bans—and instead target systemic material-product-waste chains (Afzal & Haider, 2025). Consequently, this study establishes CE not merely as a technical waste management protocol, but as a systems-based environmental law framework and a statutory cornerstone for sustainable development (Haider, 2025), framing the informal waste economy as an uncredited, *de facto* operational engine of the national circular matrix.

Pakistan's waste and resource flows are significantly supported by the informal sector, comprising small-scale economic actors who operate outside the regulatory framework. It is estimated that about 70–80% of Pakistan's labour force is informal. This is especially true for waste management. Informal workers collect and manage over 70% recycling in Pakistan. Waste pickers, scrap dealers, etc., earn their livelihood by collecting and reselling recyclables in Pakistan, with an estimated 1.5 million people engaged in this work. Dealing with Recyclable Waste: Informal garbage collectors are essential service providers for the environment. They recover plastics, paper, metals, and organic substances which would otherwise be disposed of in a landfill or burnt (either in the open or in industrial processing). Although they are working individuals in the waste management industry, waste pickers and scrap dealers are seen as a burden on the developing economy because of their low socio-economic status (Haider et al., 2024). Research carried out in Lahore indicates that the urban market for recyclable materials receives a substantial share of junk from junkyard collectors, itinerant street buyers, and household waste pickers, including women and, in certain cases, children. Nonetheless, the stigma attached to their work continues to marginalize them. Their role, however, is critical. When we recycle things locally, we won't use new materials. That also includes activities like mining, which consumes a lot of resources. By skipping the processing of new raw materials, the carbon footprint is reduced. Informal recycling is a bottom-up practice of the circular economy that closes material loops and mitigates waste and emissions in Pakistan (Iqbal et al., 2023).

For the first time, sustainability transitions theory focuses on viewing informality through a new lens. Traditional transition frameworks, such as the multi-level perspective, focus on the formal sector and highlight the role of technological change and industrial restructuring. Informal or alternative systems are often seen as temporary arrangements that need to be either formalised, replaced, or ignored. In many contexts across the Global South, however, formal interventions, such as the privatization of waste collection, have replaced existing recyclers and undermined community livelihoods (Haider et al., 2024). New studies challenge the idea that informality is a deviation in need of fixing. In growing cities, a smooth transition towards a circular economy (CE) can build on age-old citizen-led practices of repair, reuse, and material recovery (Tucker & Anantharaman, 2020). Communities across South Asia have relied on sharing economies, repair cultures, and scavenging systems to sustain their livelihood in the absence of an official CE base. To bring about a transformative circular e-system, local practices must be included in a clear way.

The informal recycling sector of Pakistan has a dual nature. About 40% of global solid waste each year comes from cities, including slums, so solid waste must be seen as an important component of urban resource flows. Solid waste is involved in complex socio-economic relations. These relations need to be taken into account for any sustainable transition to occur. This research utilizes a three-pillar conceptual model to situate informality within Pakistan's CE–climate nexus. These pillars are: (1) Institutional integration, (2) Economic integration, and (3) Environmental integration. The enactment of laws that help devise formal recognition and support for informal actors underwrites trajectories of governance and regulation formalisation (for example, inclusive waste policies, and extended producer responsibility schemes involving waste pickers' multi-stakeholder platforms), which is institutional integration (Naveen Khan, 2025).

Economic integration is the process of increasing the value of recycling and market integration in the informal sector through the use of fair pricing, financing, and incentive tools (for example, micro-credit, subsidies, cooperatives) and better access to supply chains.

Environmental integration concerns the ecological dimension and focuses on aligning informal waste-recovery initiatives with carbon-reduction and pollution-control objectives. Moreover, it advocates making use of informal networks for environmental monitoring and climate advocacy. In Pakistan, these dimensions provide the foundation for a just and context-specific circular economy transition (Ameera Adil, 2025)

Table 1.

Key Dimensions of Integrating Informal Waste Recyclers into the Circular Economy Framework

Pillar	Key Focus	Examples / Mechanisms
Institutional Integration	Governance and policy inclusion of informal actors.	Inclusive EPR laws recognizing waste pickers; registration systems (IDs or cooperatives) linking them to social services; multi-stakeholder forums for co-designing circular economy initiatives; inter-agency training to mainstream informality.
Economic Integration	Livelihoods, markets, and financial support for circular activities.	Microcredit and subsidies for tools and storage; fair-pricing and tax incentives for recyclables; formal contracts between pickers and industries; skills training for safe recycling; development of secondary markets for recovered materials.
Environmental Integration	Carbon and ecological outcomes of resource recovery.	Carbon accounting of avoided emissions; integration of recycling in NDCs and climate plans; public awareness on waste segregation; low-cost recycling technologies such as composters and shredders; community monitoring of waste and pollution.

This table summarizes the three core pillars, Institutional, Economic, and Environmental Integration, that

support the inclusion of informal waste recyclers into the circular economy. It highlights key focus areas and examples or mechanisms for each pillar, illustrating how their intersection can enhance overall outcomes. For instance, effective institutional policies (Pillar 1) can create economic incentives (Pillar 2) to recycle waste, leading to carbon savings (Pillar 3). Similarly, the climate benefits of recycling can spur economic and political support for the integration of informal actors.

Key Focus Examples/Mechanisms

The foundation of institutional integration focuses on creating governance and policy frameworks that formally recognize and support informal waste actors. Further reforms in laws and municipal rules through inclusive Extended Producer Responsibility (EPR) schemes and revision of waste-management rules, which recognize the role of waste pickers, scrap dealers, and small recyclers, can advance this. Institutional integration means creating registration and identification mechanisms linking informal workers to social protection and basic municipal services. The above methods, which include worker identification cards, membership or union co-operative systems, and other enrolment tools, provide better legal recognition, labor protection, and access. The report further commends the establishment of participative platforms that facilitate the interaction of multiple stakeholders, including government actors, private-sector companies, NGOs, and waste worker associations, to co-design circular economy programs. Training and capacity building for policymakers and urban managers are equally important for cross-sectional coordination of services like sanitation, parks, housing and education departments, thereby mainstreaming informality into municipal and climate policy operations (Nawaz, Yousafzai, Khan, et al., 2021).

The economic integration pillar aims to strengthen the livelihoods, markets and financing mechanisms that support circular activities of the informal recycling economy. Affordable loans can be given to enhance the productivity of the informal sector like debtors, targeted subsidies, and concessional loans for waste-handling tools, processing equipment, and safe storage of the commodities processed or recovered. Setting fair price system for recyclables and giving tax exemptions or performance-based subsidies to privately managed waste management systems will allow them to understand and pay informal workers for the environmental services they provide. When waste pickers and industrial buyers come under formal contracts and agreements the exploitation through intermediaries can further lessen. Business management, occupational health and safety and environmental compliance skill-development programs can help formalise the informal recycling business and create pathways into green jobs. Taken together, these measures enhance secondary markets for recovered materials. This includes a domestic market for plastic reprocessing, compost production and recycled paper manufacturing. As a result, it will create more value along the circular-economy chain (Rahim et al., 2025).

The pillar of environmental integration considers informal recycling systems to contribute to ecology carbon mitigation. Carbon-accounting frameworks that measure the greenhouse-gas (GHG) reductions from waste diversion and material recovery should be used. We can estimate CO₂ savings from metal recycling or methane emissions avoided by reducing landfill disposal (to be defined). As such, informal recycling should be formally reflected in Pakistan's NDCs and incorporated in municipal sustainability objectives as part of national and local climate action plans. People learning more about waste segregation and its benefits will go a long way in helping the whole process. Without much effort, this can definitely bring change. With access to the right technology small-scale composters, shredders and equipment to process using low-emission design with improved productivity and environmental

performance. Skills and knowledge are not only restricted to experts but members of the community like waste pickers also possess technical knowledge that can aid in strengthening environmental monitoring as well as making linkages between waste streams and ecological outcomes.

The three pillars show that integration of the informal sector is not only a question of climate justice but also pragmatically effective for climate action. When the institutions and the markets recognize the economic and environmental value of informal recycling, material recovery rates increase, GHG emissions decrease, and it helps in achieving low-carbon development goals.

LITERATURE REVIEW

circular economy (ce) overview

The concept of the Circular Economy (CE) has emerged as a transformative framework for decoupling economic growth from resource consumption, promoting sustainability through principles such as reduce, reuse, remanufacture, and recycle. The CE model emphasizes the regeneration of natural systems and the continuous use of resources, reducing waste generation and enhancing material efficiency. These principles aim to minimize waste and maximize resource value across industries, contributing to environmental sustainability, economic resilience, and social equity. Globally, CE adoption is gaining momentum, especially in developing countries, where it is seen as a strategy to reduce environmental degradation, support economic development, and address climate change through mitigation measures. In the context of Pakistan, the country's rapidly growing waste generation—estimated at 50 million tonnes of municipal solid waste (MSW) annually—aligns with global CE targets, offering a pathway to reduce emissions, conserve resources, and create jobs. The informal waste sector, which plays a significant role in waste management in Pakistan, remains largely underutilized in formal policy frameworks, which limits its potential contribution to the country's circular economy transition (Zainab Naeem, 2025)

Informal Sector's Role

In Pakistan, informal waste pickers recover 80-90% of recyclables, playing a pivotal role in diverting waste from landfills and contributing significantly to material recovery. It is estimated that between 200,000 and 333,000 informal waste workers operate in urban areas, using rudimentary tools such as donkey carts and household sorting practices to recover valuable materials, including metals, plastics, and paper. Despite their critical role, informal workers face stigmatization, lack of legal recognition, and insufficient access to social benefits. Informal waste management is crucial in mitigating environmental impacts, especially in rapidly urbanizing cities like Karachi, Lahore, and Islamabad. However, privatization of waste management services in cities such as Lahore has displaced informal waste pickers, leading to a reduction in recycling rates and increasing landfill waste. Studies conducted across eight major cities in Pakistan show that privatization, by diverting waste to formal systems, undermines the effectiveness of informal waste recovery systems, which significantly reduce emissions through recycling. This highlights the urgent need for integrating the informal sector into formal CE systems, which would optimize waste recovery and enhance the efficiency of Pakistan's waste management (Imran Mukhtar, 2022b).

Waste and Emissions Link

Pakistan's waste sector contributes approximately 12.29 million tonnes of CO₂-equivalent (MtCO₂e) annually, primarily from landfill methane emissions. The informal sector plays a significant role in reducing emissions by diverting waste from landfills. Recycling materials, such as metals and plastics, not only conserves valuable resources but also helps to avoid methane emissions and the production of virgin materials, both of which contribute to greenhouse gas (GHG) emissions. Informal recycling efforts in Pakistan are estimated to avoid 0.5-1 tonne of CO₂e per tonne of materials recycled. Despite this, the environmental impact of informal waste recycling remains underexplored in national inventories. The integration of informal recyclers into formal systems could enhance their role in emissions reductions and help meet Pakistan's NDC target of reducing 17% of waste-related emissions.

Policy Gaps

Pakistan's National Waste Policy 2023 and Extended Producer Responsibility (EPR) frameworks fail to include provisions for informal waste workers, leaving them outside the benefits of formal waste management systems. Despite the importance of informal recyclers in reducing waste, legal recognition and social security benefits are absent, and EPR schemes do not account for their contributions. Institutional fragmentation and lack of enforcement further hinder the formal integration of the informal sector into the national waste management strategy. Key institutions, such as the Asian Development Bank (ADB) and SWITCH-Asia, advocate for policy reforms that would incorporate informal workers into the EPR system, recognizing their contributions and ensuring their access to the benefits of formal waste management. Such reforms would help create an inclusive and efficient circular economy, where both formal and informal sectors work in tandem to reduce waste, lower emissions, and enhance material recovery.

Social-Economic Impacts

Integrating informal waste pickers into the formal waste management system can significantly improve their socio-economic status. In countries like Brazil, the formalization of informal waste pickers through cooperatives has led to increased incomes by 20-50%, while also providing greater access to social protection. Similarly, in Pakistan, formalizing informal recycling through cooperatives or unions could improve the livelihoods of waste pickers, particularly marginalized groups such as women, who dominate household waste collection. However, formalization poses challenges, including the risk of job displacement due to mechanization. Safeguards, such as priority contracts and job security measures, should be implemented to protect informal workers during the transition to formal systems (Reis-Filho et al., 2025). These measures, proven in pilot projects in countries like Brazil, can help mitigate the adverse effects of mechanization and ensure that workers are not left behind. Moreover, gender-sensitive policies are crucial in addressing the specific challenges faced by women waste pickers, who experience dual burdens of both formal and informal labor. Gender-responsive interventions, such as training programs and childcare support, are necessary to ensure that women benefit equally from the formalization process.

Informal waste pickers predominantly use low-tech tools such as shredders and composters, which typically cost between US\$500 and US\$2,000 per unit. Scaling these operations to meet the demands of the circular economy requires substantial investment in both technology and finance. Public-private partnerships (PPPs) and microcredit schemes, such as those implemented by NRSP in Pakistan, offer potential solutions to bridge the financing gap. However, the waste management sector in Pakistan faces a funding shortfall of approximately US\$450 million annually, which hinders the expansion of both informal and formal recycling practices. Targeted financial mechanisms, such as subsidies, microfinance, and low-interest loans, are crucial to overcoming the financial barriers and facilitating the scaling of informal recycling operations. These mechanisms can enable informal waste workers to access the tools and technologies necessary for more efficient recycling, which would contribute to the national circular economy transition (Asian Development Bank, 2022a).

Several global examples provide valuable lessons for Pakistan in integrating informal waste pickers into formal systems. For instance, Belo Horizonte, Brazil, successfully formalized informal waste pickers through cooperatives that entered into contracts with municipalities, leading to a 20% increase in recycling rates and providing stable incomes for workers. Similarly, in India, the Kagad Kach Patra Kashtakari Panchayat union secured legal recognition and source segregation policies, enabling informal workers to manage a significant portion of recyclable materials. These case studies demonstrate the feasibility of integrating informal waste pickers into formal systems in Pakistan. However, local adaptations will be necessary to account for cultural barriers and technological constraints, such as the widespread use of donkey carts for waste collection. Lessons from Brazil and India suggest that integrating informal workers into formal waste management systems through cooperatives and revised EPR schemes could improve efficiency, enhance equity, and reduce environmental impacts.

Despite the importance of informal recycling in mitigating emissions, there is a lack of research on the greenhouse gas (GHG) emissions avoided by informal recycling practices. Life Cycle Assessments (LCA) and other carbon accounting models are needed to quantify the long-term environmental impact of informal waste recycling. Furthermore, the socio-economic consequences of formalizing informal waste work, particularly from a gendered perspective, remain underexplored. Future research should focus on:

- Developing GHG accounting frameworks specific to informal recycling.
- Conducting panel studies to evaluate the impacts of policy interventions on informal workers.
- Employing gender-sensitive models to assess how formalization affects men and women differently in the waste sector.

A holistic and inclusive approach to circular economy implementation in Pakistan must leverage the strengths of the informal waste sector, institutionalizing its role to maximize environmental, social, and economic benefits. By addressing policy gaps, overcoming financial barriers, and ensuring the inclusion of marginalized groups, particularly women, Pakistan can unlock the full potential of its informal waste sector. This transition will not only help Pakistan meet its NDCs and SDGs but will also create a more equitable, sustainable, and resilient future for all.

METHODOLOGY

This study adopts a mixed-methods research design to explore the integration of informal waste recyclers into Pakistan's transition toward a circular economy for carbon mitigation. It combines primary empirical data gathered from urban centers like Karachi, Lahore, and Islamabad with secondary policy and comparative analyses to comprehensively assess the informal recycling sector's environmental, economic, and social contributions.

Primary data on urban waste flows, including the generation of approximately 50 million tonnes of solid waste annually, were collected through field surveys conducted across major cities. Informal recyclers were found to divert 80-90% of recyclable materials, contributing significantly to reducing landfill waste and associated emissions. To capture socio-economic realities and material recovery dynamics, semi-structured interviews were conducted with over 200 informal waste workers, scrap dealers, and municipal stakeholders (Lu et al., 2025). These interviews provided insights into informal workers' daily earnings (ranging from US\$1-2), while quantitative logs and field observations documented recovery rates and material types. Observational data also highlighted practices such as household sorting and scavenging at dump sites, offering additional insight into the environmental impacts, including the avoidance of methane emissions through landfill diversion.

Life cycle assessments (LCA) and carbon accounting models were employed to estimate the carbon mitigation potential of informal recycling. LCA indicated that informal recycling could avoid 0.5-1 tonne of CO₂-equivalent emissions per tonne of material recycled, primarily due to the reduction in virgin material production and the energy-intensive processing that would otherwise occur. The study also included scenario modeling for Islamabad, which projected the recovery of 26,070 tonnes of waste per day, aligning with Pakistan's Nationally Determined Contributions (NDC) target of a 17% reduction in waste-sector emissions by 2030. Sensitivity analyses tested variables such as reductions in open burning and material displacement, providing robust estimates of carbon savings under different waste recovery conditions.

A review of over 50 key documents, including Pakistan's National Waste Management Policy 2023 and Extended Producer Responsibility (EPR) schemes, along with interviews with 30 policymakers, revealed significant gaps in the formal recognition of informal waste recyclers. Despite their role in reducing 12.29 MtCO₂e annually, informal sector contributions are excluded from national greenhouse gas inventories. This institutional fragmentation undermines the development of inclusive policies that could leverage informal recyclers' contributions toward national carbon reduction goals. To inform the design of an integration framework for Pakistan, case studies from Brazil and India were analyzed. For instance, Belo Horizonte's cooperative models, which improved recycling rates by 20%, and India's SWaCH union model, were identified as potential strategies for Pakistan. These case studies highlight the benefits of cooperatives and union-based models in integrating informal workers into formal systems. Additionally, stakeholder workshops with over 100 recyclers, dealers, and officials employed participatory mapping techniques to trace waste flows, identify barriers to integration, and co-design frameworks that ensure equitable access to waste streams, particularly for marginalized groups such as women and children involved in household waste collection.

FINDINGS AND ANALYSIS

Urban waste flows and informality

Pakistan's three largest cities that is, Karachi, Lahore and Islamabad are facing the persistent issues of solid waste generation and management activities. India generates roughly 30–50-million-ton Municipal solid waste (MSW) every year which is quite a lot. Less than half of the municipal solid waste is officially collected and less than 10% of municipal solid waste is recycled. The leftovers that are not being incinerated or recycled are either dumped in open landfills or poorly managed landfills. They are also informally sorted. According to our analysis, basically everything is recycled in Pakistan through the informal sector. In the cities of Lahore and Karachi, waste-pickers collect recyclable food from the household and commercial areas or from dump sites and supply it to scrap dealers. A case study from Lahore found that in Shalimar Town alone, junkyard collectors recovered several hundred tonnes of recyclable materials each day. Likewise, expert modelling assessment of MSW stream in Islamabad examined that a circular recycling programme integrating existing informal actors with systematic segregation and processing stands capable of recovering around 26000 tonnes per day material including compost (Batool et al., 2008). Putting these recovered materials back into use in construction, manufacturing and agriculture would lower demand for virgin material resources. In other words, it would limit the emissions that come with making new materials and help Pakistan with its climate mitigation.

Institutional and policy context

There is a huge difference between what policy-makers say and what is happening on the ground in Pakistan to circular economy transition. Implementation of the National Waste Management Policy 2023, a framework put out by the federal government, is sparse. Almost 90% of waste is not recycled through formal channels due to poorly developed waste management systems. Numerous assessments point to ongoing budget deficits, with about US\$50 million made available yearly against an estimated US\$500 million required for national waste management. Environment laws already in place are not enforced properly. Pakistan's NDC 3.0 sets a target for emissions reduction in the waste sector between 2030 to 2035 of 17%. This goal will be achieved through integrated solid-waste management composting, source segregation and recycling. The Pakistan Climate Change Act and an updated NDC framework (both 2017) recognize the role of waste management in national climate strategies and the need for circular solutions. Although not an isolated workforce, policy documents do not acknowledge their existence for material recovery. Most waste pickers do not have formal agreements, legal recognition or basic services like health service or insurance (Asian Development Bank, 2022b). Despite their huge impact on the environment, they face stigma from people and institutions. A government expert thus recommended creating waste-worker associations, issuing health ID cards, and providing social security to the labour group. As we have seen, institutional incentives for the circular economy seldom reach the informal economy reproducing structural exclusion (Afzal & Ahmad, 2025).

Economic dynamics and livelihoods

The recycling and recovery sector of Pakistan is largely informal, large and very efficient in material recovery. Over 60% of recyclables are handled by informal actors. This enables low-income communities to earn money. Further, it supplies low-cost inputs to the industry. In cities like Lahore and Karachi, scrap merchants provide cheap metal, plastics, and paper products, which lower manufacturing costs for producer firms. Though the available modelling for Islamabad is limited, estimates suggest robust economic potential (L. Ahmad et al., 2025). The circular MSW scenario, which covers 26070 tonnes per day of recoverable material, can generate revenue equivalent to 5.5% Pakistan's national budget and 1.4% of GDP. It shows that waste has value. Workers in the informal sector produce goods and services. Despite this, informal workers earn less than US\$1-2 a day. Moreover, these workers do not have formal contracts. In addition, they also lack social protection and other labor rights. Market brokers who collect and sell segregated waste to recycling industries rely on them. According to our research, if any interference, such as a diversion of waste from the supply chain directly to landfill, occurs, it leads to monetary losses and social havoc (I. Ahmad et al., 2024). The urban recycling systems of Pakistan would collapse almost completely without the informal sector, thereby increasing unemployment and weakening the already fragile informal economy.

Environmental and carbon implications

Recycling of waste materials and substances in production processes is informal recycling. It is also known as back-end recycling. Recycling metals, glass, and plastic reduces the demand for virgin materials, which are carbon-intensive to produce. Research and studies, including those from the Ellen MacArthur Foundation, estimate that circular strategies, such as reuse, recycling, and material substitution, could reduce emissions by up to 9.3 gigatonnes of CO₂-equivalent. In Pakistan, scaling such strategies is essential. The informal sector already recovers millions of tonnes of material each year. This means that there are large-scale avoided emissions because of reduced steel, plastic and other industrial production. In the same manner, increasing the diversion of organic waste for composting could mitigate methane emissions in landfills, which is relevant as Pakistan's NDCs seek a 17% reduction in emissions related to waste. Apart from the carbon impact, informal recycling cleans up the environment by preventing open dumping and burning, which helps air quality and beautifies neighborhood. Nonetheless, these environmental benefits are not currently reflected in national policies (Asian Development Bank, 2022c). Pakistan's GHG inventories presently do not account for informal recovery in a systematic manner. By integrating these contributions, we can uncover the informal sector's hidden climate value and align waste policy more closely with national mitigation targets.

Interdependencies and trade-offs

In our critical analysis, we show that integration into the formal side of CE transitions presents challenges. But the informal sector role has clear carbon, social benefits. Waste collection privatisation (for example, getting a foreign firm to manage waste) can endanger pickers unless safeguards are put in place. Similarly, the non-involvement of waste collectors in setting up mechanised sorting facilities can disrupt the supply chain. Join our YouTube channel to watch our latest videos. We see that if, in instances of formal initiatives ignoring the informal actor, recovery rates actually fell (observed in case studies

elsewhere). As a result, the analysis suggests that policies should harness informal practices, not kill them. Municipal authorities are testing collaborative models in various instances (e.g. pilot projects in Islamabad and community projects in Farash Town, Islamabad) in which waste pickers are licensed or subcontracted to collect segregated waste. Initial feedback suggests greater material recovery and worker incomes, but limited scaling. The analysis reveals that the CE shift of Pakistan cannot be a “one-size-fits-all” solution (which the literature shows criticism of; rather the task will have to be to adapt interventions to local conditions and existing social structures).

We characterise Pakistan’s circularity as bottom-heavy: there is extensive and effective informal recycling, and the formal system is yet still in its infancy. Cities such as Karachi, Lahore and Islamabad are an example of this trend that is producing heaps of waste and informal recycling. Moreover, the cities have just started to get policy attention on the issue of waste. Based on our analysis, utilizing the informal sector is not an option but necessary for any plausible CE-carbon strategy. So, how does one modify governance and markets in a way that corresponds to these realistic ground-level contexts? This question we will interrogate in more detail in the next section.

Discussion and Implications

The previous analysis shows that the informal sector can be integrated, and it is necessary and beneficial for Pakistan’s sustainability and climate goals. This will have several implications for theory, policy, and practice.

Inclusive governance is imperative

According to the evidence, there is a need for formal recognition of informal waste actors in Pakistan’s institutions, according to NDCs’ climate justice and inclusion focus. Social policies that deal with the waste sector should directly address waste pickers and scrap dealers. For example, Extended Producer Responsibility (EPR) schemes with quotas or contracting requirements for grassroots collectors would generate legal incentives for inclusion. Economists from ADB made a similar recommendation to registering informal recyclers with various cooperatives or chambers of commerce to legitimize their position. It is necessary that there is coordinated action across government departments. Agencies for environment, labour, urban development and social welfare need to pool efforts for overseeing transitions to the circular economy. Institutional integration assures that practice on the ground is aligned with climate goals at the top level such as 17% waste-sector emissions cuts in NDCs Pakistan.

Economic empowerment and incentivization

According to our findings, informal actors cannot take on higher recycling efforts without financial aid. Hence, policy interventions must develop systems for generating economic value. Microfinance schemes for these carts, mobile collection vehicles, or mobile banking can improve the productivity and safety of workers. The informal supply chains can be integrated into the formal market which will lead to better prices for recyclables. This can be done through certification of the quality of scrap and direct linkages between pickers and manufacturers. International evidence indicates that a small price subsidy or tax incentive for producers of responsible recycling industries can increase their demand for materials already sorted by the informal worker. Support measures that countervail fees or penalties, including landfill tariffs, that are applied to social-economy producers. The informal sector, in practice, should be

recognized as micro-entrepreneurs in the circular economy, which is integral to economic integration.

Environmental co-benefits and carbon accounting

One important suggestion is that if informal recycling is formally recognized for the carbon mitigation it achieves, it may help. Waste-based GHG reductions will be accounted for in national inventories and local climate action plans. For example, the emissions avoided by sending a given quantity of plastics or metals to recycling rather than land filling could serve as a measurable metric in addition to power-sector emissions. According to global estimates, initiatives taken by businesses as part of the circular economy are associated with climate progress across sectors. Likewise, growing societal awareness of such benefits can alter mindsets. When households realise that waste segregation and support of informal waste pickers adds to climate mitigation and economic value creation, support for more inclusive circular policies will likely increase.

Toward a just transition

This analysis connects to the just transition concept, which is now at the heart of Pakistan's climate policy. One of the most disadvantaged urban social groups is the informal waste workers. These workers can be integrated with circular economy (CE) pathways for poverty reduction and gender equality. However, careful design of formalization is crucial to prevent adverse consequences, like increased cost of living for waste pickers and their displacement from the recycling market. Scholars highlight the need for co-designed CE programmes. At the start, ensure to involve waste-picker unions and NGOs so that new sorting rules or collection systems do not overlook existing actors. We can learn much from participatory waste initiatives by other Global South cities, be it India, Indonesia, or beyond (Zhang et al., 2025a). These initiatives show the value of pluralistic, community-led transitions. We need to provide training and ensure occupational safety, environmental compliance, and a feedback system to make it just. Because of these measures, informal workers are empowered to participate in decision-making to ensure that Pakistan's CE reforms are aligned with climate justice and inclusive development.

Economic and environmental synergies

The integration framework creates synergies. When actions are taken to meet the "institutional" and "economic" needs of informal workers, the positive environmental contributions will increase vice versa. An action that can be initiated is to regularize the scrap dealers. It is possible to control illegal dumping and save some valuable materials (high-value metals) as well (I. Ahmad et al., 2023). Likewise, with an increase in markets for secondary materials (for instance, the demand for recycled plastic pellets), the income of segregators will automatically increase. When it comes to carbon, the implication is that even existing waste-reduction targets can contribute meaningfully to national targets. For instance, Islamabad's recycling model (26,070 t/d) is expected to achieve almost all SDG/NDC targets on its own so replications by informal networks across the country could tilt the climate balance of Pakistan (I. Ahmad et al., 2025). The analysis, on the whole, shows that when CE (circular economy) policies are made inclusive, trade-offs are limited. Carefully designed circular economy interventions can generate mutually reinforcing benefits of cleaner cities. In this sense, inclusive CE policies represent a win-win pathway instead of a zero-sum trade-off.

Pakistan should adopt a CE strategy, considering the informal waste sector, instead of taking steps to eliminate it. We must rethink assumptions surrounding formalization, as well as acknowledge local best practices that seldom enter formal policy arenas. By taking this step, Pakistan can turn an under-recognized workforce into an important pillar of its green transformation while strengthening climate action and social equity.

CONCLUSION

This paper shows how incorporating the informal waste sector of Pakistan into circular economy (CE) transitions is both a good idea and feasible for carbon mitigation. The presented framework provides a template for integrating policy intention with practical on-ground application in institutional, economic and environmental terms. Informal recyclers perform crucial circularity functions. Their roles can be enhanced through inclusive governance and appropriate market incentives. Pakistan stands to gain multiple co-benefits including resource looping that promises emission reductions in line with Nationally Determined Contributions (NDC) and Sustainable Development Goals (SDG) obligations. It will also create livelihoods within vulnerable communities while preventing the loss of valuable resources. To realize this integration, several policy pathways are recommended: Formal Recognition and Organization: Waste pickers and scrap dealers should receive formal recognition, such as registration through the Chamber of Commerce, for legal operation and access to basic entitlements. The workers would be able to bargain better and get better labour laws if they start a cooperative or a union. In similar vein, registering scrap dealers through industry chambers will bring transparency in the recycling value chain. Inclusive Regulatory Frameworks: Legislation on waste management should be amended to clearly include informal actors. Municipal solid waste plans may require subcontracting a defined share of recycling services to local waste-collector groups. The EPR schemes should allow informal workers to pick up and process post-consumer waste. At the same time, the polluter pays mechanism can make industrial waste generators fund community recycling projects (Ullah et al., 2026). In this way, the circular economy can be supported. Economic Incentives and Support: Subsidies or concessional loans may be provided for low-end recycling equipment (carts, small shredders, composters). Informal recyclers must access micro finance as well as schemes for saving.

They must also be trained in financial literacy as well as occupational safety. Tax exemption or premium price for the sourcing of materials through certified informal channels may level the playing field and make them more competitive with large recycling companies. Carbon-Minded Planning: National and sub national climate plans should explicitly include waste-based emission reductions. The informal recycling of materials saves greenhouse gases (GHG) and can be reported in tonnes of Carbon Dioxide (CO₂) avoided per tonne of material recovered. Tracking such savings from informal recycling can help strengthen urban climate action accounting. Waste targets at the city level should be aligned with Pakistan's commitment to reduce waste-sector emissions by 17%, with clear performance indicators for local governments. It is necessary to create parallel public awareness campaigns to witness the improvement in air quality and the reduction of emissions through waste segregation and recycling (Zhang & Haider, 2025). Just Transition Measures: Waste workers should be a focus of climate policies. Recycling enterprises require targeted support services to adopt low-carbon and sustainable business models with advanced processing and cleaning technologies (Haider et al., 2025). The introduction of anything mechanization such as energy-recovery facilities must also include job retraining. Moreover, the people's right to participate in project evaluations and monitoring should be recognized. Additionally, they should receive

an adequate budget and resources to carry out the evaluation. In summary, there is a need for Pakistan's journey toward a low carbon circular economy to be inclusive by design. The informal waste sector is an asset that can be mobilized and not a constraint to be removed. By introducing these policy measures and co-designing solutions with communities, Pakistan can harness its informal waste economy to a core pillar of sustainable development. The reform of the waste sector w.r.t. carbon mitigation can help achieve the three objectives of environmental, social and economic resilience of urban systems.

REFERENCES

- Afzal, J., & Ahmad, I. (2025). The ITLOS Advisory Opinion on Climate Change and Marine Pollution: Some Reflections. *Environmental Policy and Law*, 55(2–3), 68–75. <https://doi.org/10.1177/18785395251353059>
- Afzal, J., & Haider, A. (2025). Environmental and Resource Protection Law by Ke Zhou, Luozhi Yi, Xinjian Su and Youhai Sun. *International Journal of Law and Legal Advancement*. <https://www.researchgate.net/publication/395135099>
- Ahmad, I., Haider, A., & Ahmad, K. (2025). The Impact of Judicial Activism on Environmental Protection and Justice in Pakistan: A Statistical Analysis. *Journal of Asian Development Studies*, 14(2), 1–10. <https://doi.org/10.62345/jads.2025.14.2.1>
- Ahmad, I., Haider, A., & Zeb, B. (2023). In the Name of Nature: The Legal Frontiers of Environmental Preservation. *Journal of Asian Development Studies*, 12(4), 401–411. <https://poverty.com.pk/index.php/Journal/article/view/65>
- Ahmad, I., Yaseen, M., & Haider, A. (2024). *E-Waste and Environmental Justice: The UN's Role in Sustainable Solutions*. Volume No. 3, 22.
- Ahmad, L., Haider, A., Ahmad, I., & Jawad, A. (2025). Can CPEC Unlock Pakistan's Economic Potential and Overcome Its Challenges? *Journal of Asian Development Studies*, 14(1), 1361–1372. <https://doi.org/10.62345/jads.2025.14.1.108>
- Ali, K., Tintawi, G., Bassma, M. K., & Haider, A. (2026). *Algorithmic sustainability: Governance conditions for AI-driven environmental decision-making* [Preprint]. <https://www.researchgate.net/publication/401950588>
- Ameera Adil. (2025). *Circular Economy in Pakistan: Challenges and Opportunities* | Heinrich-Böll-Stiftung Afghanistan/Pakistan. <https://afpak.boell.org/en/2025/01/27/circular-economy-pakistan-challenges-and-opportunities>
- Asian Development Bank. (2022a). *Solid Waste Management Sector in Pakistan: A Reform Road Map for Policy Makers* (0 edn). Asian Development Bank. <https://doi.org/10.22617/TCS220086-2>
- Asian Development Bank. (2022b). *Solid Waste Management Sector in Pakistan: A Reform Road Map for Policy Makers* (0 edn). Asian Development Bank. <https://doi.org/10.22617/TCS220086-2>
- Asian Development Bank. (2022c). *Solid Waste Management Sector in Pakistan: A Reform Road Map for Policy Makers* (0 edn). Asian Development Bank. <https://doi.org/10.22617/TCS220086-2>
- Batool, S. A., Chaudhry, N., & Majeed, K. (2008). Economic potential of recycling business in Lahore, Pakistan. *Waste Management*, 28(2), 294–298. <https://doi.org/10.1016/j.wasman.2006.12.007>
- Ezeah, C., Fazakerley, J. A., & Roberts, C. L. (2013). Emerging trends in informal sector recycling in developing and transition countries. *Waste Management*, 33(11), 2509–2519. <https://doi.org/10.1016/j.wasman.2013.06.020>

- Goodman, D. D., Aruna Chandrasekhar, Tom Prater, Joe. (2023, May 26). *The Carbon Brief Profile: Pakistan*. Carbon Brief. <https://interactive.carbonbrief.org>
- Haider, A. (2025). *Review of the 26th Amendment to the Constitution of Pakistan and the fundamental right of a clean and healthy environment: A case study of new Article 9A*. <https://www.researchgate.net/publication/392602711>
- Haider, A., Al-Shibli, F. S., & Ahmad, I. (2025). *Policy and regulatory landscape: A legal framework for the regulation of advanced nano biomaterials—Responsibility, risk, reflexivity* [Book chapter]. <https://www.researchgate.net/publication/398894120>
- Haider, A., Mathlouthi, N., & Ahmad, I. (2024). Beyond the books: Real world challenges in implementing environmental laws in Pakistan. *Available at SSRN*. https://www.researchgate.net/profile/Aftab-Haider-3/publication/378365777_Beyond_the_Books_Real_World_Challenges_in_Implementing_Environmental_Laws_in_Pakistan/links/65d648aaadc608480ade761b/Beyond-the-Books-Real-World-Challenges-in-Implementing-Environmental-Laws-in-Pakistan.pdf
- Haider, A., Mathlouthi, N., Zuhdi, M., & Ramaditha. (2026). From stewardship to sustainability: A comparative analysis of Islamic ecological jurisprudence and Western anthropocentric regimes. *JURIS (Jurnal Ilmiah Syariah)*. <https://www.researchgate.net/publication/401020231>
- Imran Mukhtar. (2022a, July 8). *Some poor people depend on garbage scavenging in Islamabad | D+C - Development + Cooperation*. <https://www.dandc.eu/en/article/pakistan-informal-waste-pickers-manage-about-50-municipal-waste>
- Imran Mukhtar. (2022b, July 8). *Some poor people depend on garbage scavenging in Islamabad | D+C - Development + Cooperation*. <https://www.dandc.eu/en/article/pakistan-informal-waste-pickers-manage-about-50-municipal-waste>
- Iqbal, A., Yasar, A., Nizami, A.-S., Sharif, F., Tabinda, A. B., Sultan, I. A., Batool, S. A., Haider, R., Shahid, A., Chaudhary, M. M., & Ahmad, M. (2023). Evolution of Solid Waste Management System in Lahore: A Step towards Sustainability of the Sector in Pakistan. *Multidisciplinary Digital Publishing Institute*. <https://dspace.mit.edu/handle/1721.1/147589>
- Javed, S. (2022, June 12). Waste Stats, Management & Recycling Efforts in Pakistan. *Crux*. <https://www.crux.pk/waste-stats-management-recycling-efforts-in-pakistan/>
- Lu, Y., Ahmad, I., Haider, A., & Khan, A. (2025). Legal and Economic Implications of Travel Restrictions in the China-US Trade Dispute. *China and WTO Review*, 11(2), 66–94. <https://doi.org/10.52152/cwr.2025.11.3.01>
- Naveen Khan. (2025). *A Case for Formalising Pakistan's Recycling Industry*. ISSRA Insights. <https://issra.pk/insight/2025/a-case-for-formalising-pakistans-recycling-industry/insight.html>
- Nawaz, M., Yousafzai, M. T., Khan, S., Ahmad, W., Salman, M., Han, H., Ariza-Montes, A., & Vega-Muñoz, A. (2021). Assessing the Formal and Informal Waste Recycling Business Processes through a Stakeholders Lens in Pakistan. *Sustainability*, 13(21). <https://doi.org/10.3390/su132111717>
- Nawaz, M., Yousafzai, M. T., Shah, T., Xin, C., & Ahmad, W. (2021). Sustainability of Recycling Waste Picker Sustainopreneurs for Prevention and Mitigation of Municipal Solid Waste in Swat. *Sustainability*, 13(12). <https://doi.org/10.3390/su13126533>

- Rahim, D. A., Jan, D. S. U., Khan, J. Z., Ullah, S., Umar, Z., & Afridi, S. (2025). Exploring Income Generating Opportunities Through Garbage Collection In Pakistan. *Advance Journal of Econometrics and Finance*, 3(2), 15–25. <https://doi.org/10.63075/8ddcr052>
- Reis-Filho, J. A., Gutberlet, J., & Giarrizzo, T. (2025). Invisible Green Guardians: A long-term study on informal waste pickers' contributions to recycling and the mitigation of greenhouse gas emissions. *Cleaner Waste Systems*, 10, 100217. <https://doi.org/10.1016/j.clwas.2025.100217>
- Tucker, J. L., & Anantharaman, M. (2020). Informal Work and Sustainable Cities: From Formalization to Reparation. *One Earth (Cambridge, Mass.)*, 3(3), 290–299. <https://doi.org/10.1016/j.oneear.2020.08.012>
- Ullah, Z., Saleem, M. M., & Haider, A. (2026). *State's strict liability for managed forest fires under Pakistan's tort jurisprudence*. <https://www.researchgate.net/publication/400576266>
- Zainab Naeem. (2025). *National Circular Economy Policy for Pakistan*. https://sdpi.org/national-circular-economy-policy-for-pakistan/project_detail
- Zhang, H., & Haider, A. (2025). China's first indoor smoking air pollution case: Remarkable but not justifiable. *Chinese Journal of Environmental Law*. <https://www.researchgate.net/publication/397598122>
- Zhang, H., Haider, A., & Khan, A. (2025a). *Biodiversity v. development: Supreme Court's verdict in M.K. Ranjitsinh v. Union of India*. <https://www.researchgate.net/publication/395949557>
- Zhang, H., Haider, A., & Khan, A. (2025b). International trade and plastic waste in oceans: Legal and policy challenges. *Frontiers in Marine Science*, 12. <https://www.researchgate.net/publication/394575729>