



JUST RECYCLING:

A CLOSER LOOK AT PLASTIC RECYCLING IN INDIA

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**ASHTAKARI
PANCHAYAT**



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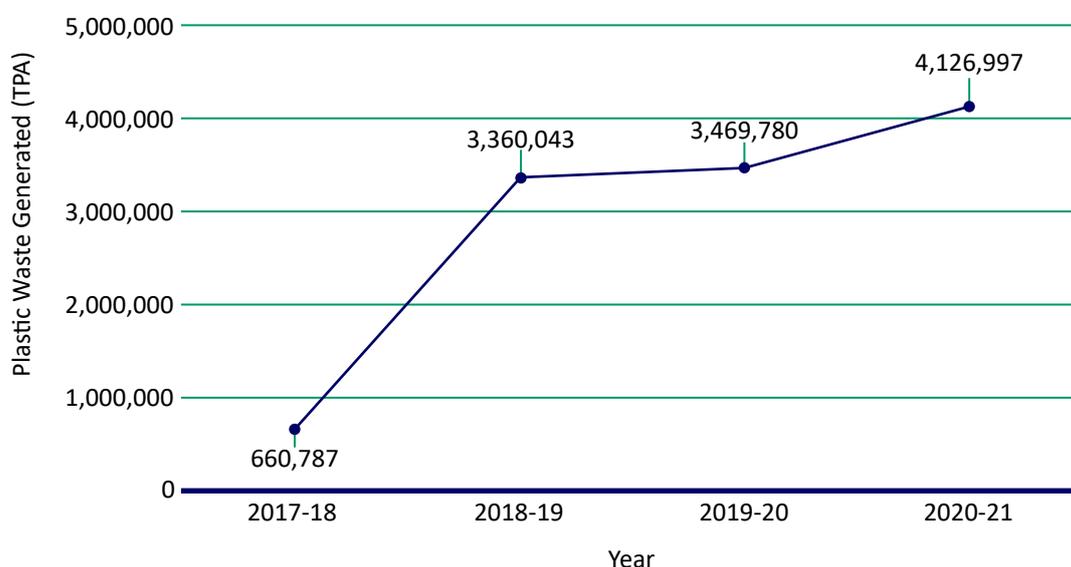
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1. INTRODUCTION

Plastics are a ubiquitous part of today's world, omnipresent in the lives of billions of people across geographic and class barriers. Durable, inexpensive, lightweight, and malleable—plastic's versatility has made it an extremely popular material for a wide variety of industries. But this was not always the case. Despite their conception in the 1930s and their introduction to mass production in the mid-1950s, the developing world was relatively slow to adopt single-use plastics. So much so that when Pune's waste picker union, *Kagad Kach Patra Kashtakari Panchayat (KKPKP)*¹, was formed in the early 1990s, plastic waste was still peripheral to the materials its members collected and sold. The union's very name— 'Paper, Glass, Metal Workers' Association' reflects the pre-plastic waste economy.

With increased globalisation, the burgeoning middle classes of the developing world, and a rise of the FMCG and e-commerce industries, this picture has changed. The plastic packaging industry in India is valued at over \$22.4 billion in 2024². The use of plastics to package food, beverages, personal care items, and household goods, among others, is at an all-time high. The UNEP reports that more plastic was generated between 2000 and 2010 than in the previous four decades combined, with nearly 400 million tonnes of plastic waste being generated each year³. The Central Pollution Control Board's (CPCB) Annual Report on the implementation of the Plastic Waste Management Rules, 2016, highlights the upward trend of plastic waste generated in the country from 2016 to 2021.

Plastic Waste Generated in India



Source: *Generation of Plastic Waste (MOEFCC, July 2023)*

¹The Kagad Kach Patra Kashtakari Panchayat (KKPKP) is a registered trade union of over 10,000 waste pickers in Pune. It has pioneered recognition of waste pickers as dignified labor, securing social security, education, and health rights for members, and co-founded the SWaCH cooperative to integrate waste pickers into municipal solid waste systems.

²<https://www.mordorintelligence.com/industry-reports/india-plastic-packaging-market>

³<https://www.unep.org/interactives/beat-plastic-pollution/>

This exponential growth has posed both opportunities and structural challenges. On the one hand, it has enabled a vast ecosystem of plastic collection, aggregation, and recycling—largely informal—that supports hundreds of thousands of livelihoods across India. On the other hand, less than 9% of plastic ever produced has been recycled⁴. The discrepancy is not merely technical but structural: municipal waste streams are heterogeneous, dispersed, and dominated by organic content, with less than 12% of waste comprising economically recoverable material. Most municipal waste management systems are not designed to capture this value effectively. The informal sector—comprising waste pickers, scrap dealers, aggregators, and recyclers—has historically filled this gap.

1.1 The Recycling Pyramid

Chikarmane and Narayan describe the recycling sector as shaped in the form of a pyramid, with decreasing levels of informality towards the top⁵. Belonging mostly to scheduled castes and minority religions, waste pickers are almost entirely informal, have the least power or say, and engage in “free” waste collection from garbage dumps, roads, and landfills without any social protections. Also involved in the collection are itinerant scrap buyers, who work in slightly better conditions, purchasing scrap in small quantities directly from households. Together, they form the base of the pyramid and are the driving force behind the recyclable plastic economy in the developing world. Their principal source of income comes from the recyclables they collect, sort into various categories, and sell to local scrap dealers.

Scrap dealers serve as monopsonies for local waste pickers and have long abused their power, either by cheating on weights or providing rates lower than the market. Operating with minimal infrastructure, restrictive zoning laws, low profit margins, and limited access to formal credit and markets, they are linked to other material-specific traders, wholesalers, and aggregators— some of whom are registered entities. Aggregators channel plastics to recyclers—both formal and informal. Recyclers sit at the top of the pyramid, dictating rates and material flows. But they, too, struggle under burdensome compliance requirements and regressive taxation policies. This whole pyramid, which bobs and weaves through formality, forms the backbone of the recycling sector in India. It is their efforts that play a pivotal role in contributing to the high plastic recovery rates in India.

⁴UNEP (2018). SINGLE-USE PLASTICS: A Rojkenz map for Sustainability (Rev. ed., pp. vi; 6).

⁵WIEGO, Chikarmane and Narayan (2005): “Organising the Unorganised: A Case Study of the Kagad Kach Patra Kashtakari Panchayat (Trade Union of Waste-pickers)”

1.2 Pune's Context

As Solid Waste Management is mandated as an obligatory function of Urban Local Bodies, there is significant diversity in the collection and aggregation systems of managing dry waste in different geographies. Integrating themselves into the city's waste management system, Pune's waste pickers under the aegis of the SWaCH cooperative, have developed a unique, decentralised, non-motorised, door-to-door waste collection system⁶. Every morning, 3900 SWaCH waste pickers collect segregated dry and wet waste from over 900,000 households across Pune. Beyond the user fees that waste pickers receive from citizens, they also retain the rights over the waste they collect, and earn around 30-40% of their monthly income from the sale of recyclables they retrieve and sell from the dry waste.

Plastics, both rigid and flexible, constitute approximately one-third of the dry household waste (approximately 100 MT/day) collected by them, and are thus a crucial source of their livelihood. Of the recyclables they segregate and sell, clear PET bottles and HDPE packaging material have the highest sale value at around ₹25/kg and ₹15-20/kg respectively, and form around 30% of the plastic waste along with other rigid plastics. But not all rigids yield a high value. For instance, black fuga and PP containers are sold for a paltry ₹6-7/kg. Prices of material depend on their recyclability, which correlates to the polymer, dye, and contamination associated with the material.

Waste pickers sell recyclables to local scrap shops, no more than 5 km away from their collection areas. The frequency of sales depends on the storage space available to them. For most waste pickers, storing recyclables in nooks and crannies of small lanes and societies is common, and they end up selling small quantities of recyclables on a daily or alternate-day basis. The overall systemic storage constraints cause most waste pickers to generally sell what is known colloquially as "mix fuga", a combination of (non-black) HDPE, PP, and in lower proportions, PET, PVC, and PS.

The scrap shops, owned mostly by men, generally found near low-income localities, with an average area of 1500-2500 square feet, also struggle with a lack of space. Stockpiling material is an impossibility for them, and they are forced to sell plastics to aggregators at extremely low or delayed (for as long as 2-3 months) payments during times of economic downturn. Waste pickers in Pune also run four cooperative scrap shops, aimed at reducing the information asymmetry and the power imbalance between retailers and collectors.

These scrap shops are (often) linked to material-specific aggregators, many of whom are located in the industrial areas to the east and north-west of the city. The aggregators generally arrange for the transport of material, with trip distances ranging between 10-25km. These aggregators sell the material to recyclers, with a bulk of the plastic sent for mechanical recycling to hubs in Malegaon, Gujarat, and Goa, travelling anywhere between 250 to 400km. Across all levels, transactions generally take place in cash due to the prohibitive 18% Goods and Services Tax (GST) on plastic waste.

⁶SWaCH, founded in 2007, is India's first waste picker-owned cooperative providing door-to-door waste collection in Pune

GST: ENABLER OF INFORMALITY

Plastic waste in India is taxed at a uniform rate of 18% under the Goods and Services Tax (GST)⁷. For most scrap shops and aggregators, operating at razor-thin profit margins, GST compliance is an almost impossible financial burden. This disincentivizes the smaller players from entering the formal economy. The four waste picker-led cooperative scrap shops across Pune also reflect the practical constraints of this dynamic: even where bookkeeping and operational systems are robust, the profit margin is too narrow to sustain tax-compliant operations.

As a result, most scrap dealers choose to remain unregistered and transact informally— according to the Centre for Science and Environment (CSE), currently over 80% of the sector is informal⁸. This, in turn, affects downstream formal entities, which either absorb the GST cost or identify intermediary vendors who can issue compliant invoices. Attempts to force formalization without recalibrating tax structures risk the collapse of the operational base that currently supports grassroots material recovery. Formalization, without enabling conditions, could shut down hundreds of small scrap businesses and exclude waste pickers from viable markets.

The pervasive informality, stemming from these regressive taxation policies, has a severe impact on government revenues. CSE's research also shows that the plastic waste market is presently valued at ₹ 36,587 crore, yet only ₹1,317 crore is realised in GST revenues—lower than the ₹1,829 crore payable under a 5% tax regime. The remaining ₹ 5,269 crore in potential GST is lost annually due to transactions occurring outside the formal tax net. Unless these policies are changed, not only does the informality get further entrenched, but government losses also continue to rise.

CSE projects that without targeted policy interventions, the informal participation rate will remain at 80% through 2035. By then, the market is expected to expand to ₹ 60,857 crore, with GST collections rising only to a modest ₹ 2,191 crore, while annual GST losses climb sharply to ₹ 8,763 crore. Integrating waste pickers, informal recycling workers, and aggregators will require policies that incentivise formal operations, simplify GST compliance for small-scale actors, and guarantee that the gains from formalisation reach those currently excluded from the formal waste economy.

⁷GST (Goods and Services Tax) is India's comprehensive indirect tax system that replaced multiple cascading taxes. Businesses with annual turnover above specified thresholds are required to register under GST and issue tax-compliant invoices for all transactions.

⁸Centre for Science and Environment, Subhrajit Goswami (2025): "Relax the Tax: Facilitating waste circularity ecosystem through GST rationalisation"

1.3 Moving Up the Value Chain

Despite their critical contribution to the plastic recycling value chain, waste pickers remain largely excluded from formal systems of governance, financing, and infrastructure. Their work is under-recognised, underpaid, and unsupported, with average daily incomes falling below the minimum wage. This reality sharpened our motivation to understand the downstream recycling sector and identify pathways through which waste pickers could be integrated into higher rungs of value addition—moving from collection to processing and production.

Kashtakari Panchayat (KP)⁹, together with SWaCH, Social Seva Initiatives (SSI)¹⁰, and Adelphi¹¹, launched Project Protoprint under the SWITCH-Asia programme¹² of the European Union. The project sought to build a city-wide, waste picker-owned recycling infrastructure that could upgrade low-value, post-consumer rigid plastics into high-margin products like 3D printing filament and plastic granules. The central thesis was that high-value addition at a micro scale, particularly for HDPE and PP, would enhance waste picker incomes, foster worker-owned enterprises, and contribute to waste picker formalisation in aggregation and recycling.

Critically, the project was designed in a bottom-up fashion. It did not rely on sourcing select high-quality feedstock from controlled environments. Instead, it committed to working with the existing mixed plastic streams—fuga, comprising HDPE, PP, PET, and PVC in post-consumer form, collected by SWaCH members. This principle ensured that the model remained inclusive, aligned with ground realities, and inclusive of the majority of waste pickers whose material recovery patterns reflect the heterogeneity of Indian waste streams.

Our learnings from setting up and operating Protoprint form the basis of this paper, which highlights the structural challenges and ground realities of the recycling sector in India. By laying out the internal workings of the units, including capital and operating costs, sourcing strategies, pricing dynamics, unit-level financial models, as well as the critical operational and bureaucratic challenges faced in setting up a “formal” aggregation and recycling entity, we aim to contribute a high level of granularity to public discourse on plastic circularity. This is intended to support policy and decision-makers in designing more grounded and inclusive systems that go beyond environmental objectives to ensure safe, fair, and legally compliant working conditions for informal workers—while remaining mindful of the financial constraints faced by these units.

⁹Kashtakari Panchayat (registered 2010) is a charitable trust established by KKPKP to support waste pickers through capacity-building, training, research, advocacy, and a helpdesk facilitating access to social entitlements, emergencies, and livelihoods—acting as a bridge between waste pickers, their collectives, and institutions.

¹⁰SSI is a social enterprise developing decentralized recycling solutions with waste pickers.

¹¹Adelphi is a German think tank on climate, environment, and development policy

¹²EU SWITCH-Asia is the European Union’s flagship programme promoting sustainable consumption and production in Asia

2. CASE STUDY: JUST RECYCLING

2.1 Vision

A scalable, replicable, compliant, and responsible recycling model for sustainable livelihoods, adhering to labour and environmental regulations within the plastic recycling value chain by integrating marginalized waste pickers into formal systems through re-skilling, context-appropriate technologies, and business-to-community linkages.

2.2 Compliance, transparency, formalisation

The project's commitment to building a clean, transparent, and responsible recycling enterprise was reflected in its compliance with statutory obligations in the transition towards formalization. This facility operates in full adherence to labor laws, including the payment of minimum wages, regulated working hours, daytime-only shifts for female staff, and the provision of social security benefits such as Employees' State Insurance Corporation (ESIC) and Provident Fund (PF) to all waste pickers employed at the unit. There is full regulatory alignment through timely GST registration, acquisition of necessary trade and operational licenses, and relevant statutory permissions and certifications required for plastic waste processing.

2.3 Timeline

The project contract agreement was formally executed in May 2020, with the completion scheduled for November 2025. The initial 12 months were focused on realigning the project design and implementation strategy to comply with the revised FCRA regulations¹³ issued by the Government of India. Subsequently, approximately six months were dedicated to identifying and securing suitable locations that met the project's pre-defined selection criteria.

An additional 15 months were spent obtaining the necessary approvals and consents—specifically the Orange Category¹⁴ classification requirements— from the Maharashtra Pollution Control Board (SPCB), which were critical for initiating formal recycling operations.

Operations commenced with single shift work days in November 2024. From May 2025 onwards, the facility was scaled up to operate in multiple shifts to accommodate increased processing capacity, optimizing operations and workforce participation.

¹³The Foreign Contribution (Regulation) Amendment Act, 2020, prohibited the transfer of foreign contributions received under FCRA to any other organization, including implementing partners located in other countries.

¹⁴Recycling units require "Orange Category" regulatory clearances from the Maharashtra Pollution Control Board, which includes a Consent to Establish and Consent to Operate. These are required before units can officially begin recycling operations. These clearances are typically subject to severe administrative red tape requiring bank guarantees, MSME certifications, registration on the EPR portal, etc.

2.4 Constraints

Site selection:

The first phase of the project was dedicated to identifying a suitable and compliant site for establishing the plastic recycling unit. This process was shaped by multiple regulatory and operational constraints. Zoning regulations mandated that the facility be located in a non-agricultural, non-residential area designated for industrial use. Operational requirements included all-weather road access, a minimum of 100 HP power supply for machinery, and proximity to waste picker communities and plastic waste sources to ensure logistical efficiency.

A key challenge encountered was the reluctance of property owners to lease premises for waste-related operations, often due to perceived reputational risks or nuisance concerns. Community acceptance also posed difficulties—sites closer to residential areas faced opposition, while remote sites risked reduced accessibility for waste workers. Additionally, financial pressures, including high rents, municipal levies, and utility costs, threatened the viability of small-scale or community-led recycling operations. Despite screening over 25 potential sites over six months, only a few met the technical, legal, and financial criteria. Ultimately, a warehouse adjacent to the highway in the Urli Devachi area of Hadapsar, Pune, was finalized after extensive negotiations and assessment.

Lack of Technical Literature and Precedents:

Across the recycling sector, information is often closely guarded, and operational knowledge tends to circulate within opaque, informal networks rather than being codified or shared publicly. Small-scale units rarely publish their technical learnings, while larger facilities operate under proprietary systems and competitive pressures that discourage transparency. The absence of documented case studies, shared learnings, or technical guidance from similar decentralized recycling models hindered informed decision-making, particularly in identifying and procuring machinery suited to our scale and operational needs. It also meant that the initiative had to rely on trial-and-error, external consultants, or piecemeal guidance from vendors, all of which increased both costs and delays.

COVID-19 and Macro Disruptions

The pandemic led to significant delays in field assessments, stakeholder consultations, and site verification processes, impacting timelines for both infrastructure planning and procurement activities during the initial stages of the project. In addition, recent geopolitical upheavals also had a severe impact on the plastic market. Virgin plastic rates for PP and HDPE have dropped precipitously over the past year leading to a commensurate decline in market rates for recycled HDPE plastic. Data from the Cooperative scrap shops run in Pune, show that fuga prices fell by about 35%: from ₹25–28/kg to ₹17–18/kg in 2024–25. This led to a supply glut, with aggregators and recyclers holding on to the pre-processed and recycled plastics awaiting an increase in selling prices, worsening cash flows even further.

Staffing Challenges:

Although most of the roles within the Recycling unit were designed for waste pickers, initial recruitment primarily drew from the nearby urban poor. Waste pickers, used to working (or aspiring to work) under the SWaCH model, which offers them agency, autonomy, and higher pay—for fewer working hours and more familiar work—were understandably disinclined to transition to a minimum wage job. Eventually, women from local communities were roped in to work at the unit.

Onboarding male workers, for some of the heavier operational tasks, also turned out to be quite arduous. The unit's location within a logistics hub offered higher daily wages through casual loading work, making formal employment—with fixed hours, lower flexibility, and social security deductions—less appealing. The absence of on-site accommodation, commonly provided in similar facilities, further deterred potential recruits. These challenges were gradually addressed through sustained engagement and awareness-building around the long-term benefits of formal employment, eventually leading to the successful onboarding of nine male workers.

2.5 Course Correction

Initially designed as a highly decentralized model comprising 50 micro-processing units (45 for collection and flaking, and 5 for 3D filament production), the project was premised on the assumption that clusters of 30 waste pickers could supply sufficient quantities of HDPE to achieve financial viability. The in-depth baseline study conducted after kick-off revealed that only 11% of the collected fuga met the quality required for filament-grade HDPE. On average, this translated to 4.5 kg/waste picker per month—far too little to sustain operations under the decentralised model.

The project realigned its processing strategy to prioritize Polypropylene (PP) waste, leveraging its price stability and demand consistency to ensure financial sustainability. Adopting a differentiated approach from typical recyclers, the facility accepted mixed-colour fuga from waste picker-run cooperative scrap shops and established vendor-specific segregation based on resin and pigment compatibility.

Nonetheless, the initiative suffered due to supply issues. Space constraints faced by waste pickers translated into inadequate sorting of retrieved fuga, resulting in only 60%—roughly 10–11 tonnes—comprising recyclable HDPE and PP, the two key polymers the recycling unit is equipped to process. Besides, most products are not designed with recyclability in mind. 26% of incoming plastics in the unit are rejected outright because they contain non-recyclable components. This heterogeneity reduces both operational and storage efficiency while increasing the need for labour.

Unlike other recyclers, across the spectrum of formality, who specialise in specific materials for this particular reason, the project decided against cherry picking materials due to the potential negative impact on waste picker livelihoods. An additional 6–7 tonnes of flaked plastic per month had to be sourced from local scrap dealers within a 2 km radius. This arrangement allowed for throughput and optimized machine utilization. Overall, this hybrid sourcing strategy—balancing direct procurement with cooperative and semi-formal intermediaries—ensured steady input flow, reduced logistical bottlenecks, and supported the goal of generating a more inclusive recycling value chain.

2.6 Operations

The recycling unit is located on the ground floor of a warehouse with a total built-up area of approximately 7,000 sq. ft. The internal layout includes designated partitions for material storage and process-specific operations, enabling efficient workflow management. The unit is equipped with key recycling infrastructure, including a cutter machine, grinding machine, washing machine, mixer machine, extrusion machine, and an effluent treatment plant (ETP), supporting end-to-end plastic waste processing on-site. 23 workers, 15 women and 8 men, are employed at the unit across two shifts, with average monthly wages of ₹18,000–₹19,500—the prescribed statutory wages for unskilled and semi-skilled industrial workers in Maharashtra under the Minimum Wages Act, as revised periodically by the state government. Women primarily manage sorting and pre-processing, washing, fine sorting, and flake storage. Male staff are engaged in core processing functions such as extrusion, grinding, and washing operations.

2.7 Current Status

Currently, over 20 MT of raw plastic waste is sourced per month from waste picker cooperative scrap shops, supplemented by 5-6 MT of plastic flakes procured from nearby scrap vendors. The unit processes and facilitates the sale of approximately 14,000 kg per month of HDPE and PP granules, along with an additional 4,000 kg per month of other plastic materials, including PET, cable insulation, toothbrushes, scrap, and other low-quality mixed-grade plastics.

PP granules are primarily sold to downstream micro and small-scale product manufacturers located within a 3-kilometre radius of the unit. One of the key buyers specializes in injection moulding processes for manufacturing household utility items such as buckets, mugs, and dustbins, while another vendor incorporates the recycled PP granules in the production of plastic ropes. Both manufacturers selectively blend the recycled granules (r-PP) with virgin or near-virgin material, calibrating the proportion based on end-product specifications and mechanical performance requirements.

Similarly, HDPE granules are supplied to a local pipe manufacturing unit specializing in agricultural irrigation products. Despite initial reluctance to establish formal procurement relationships, following sustained outreach, these vendors eventually engaged. Sharing third-party laboratory quality assessments of the granules played a pivotal role in building trust and establishing market acceptance. The vendors agreed to transact under formal terms, including accepting tax invoices compliant with the GST regime and making payments through bank transfers, as mandated under the CGST Act for claiming Input Tax Credit (ITC)¹⁵.

¹⁵However, this transition to formalized procurement introduced a delay in payment cycles. A key condition put forth by the vendors was that payments for the recycled granules would only be initiated post-sale of the equivalent quantum of material under GST, enabling them to avail of the corresponding GST offset (input tax credit) in their monthly returns. This behavior reflects a broader structural issue in the micro and small manufacturing sector. The vendors' GST liability on outward supplies had to be matched with eligible input credits from inward supplies—effectively tethering their purchasing capacity to downstream sales performance within the formal tax ecosystem. This inherent structural issue led to payment delays from these vendors, ranging from ~30-120 days.

Table 1: Average Sale rate/kg (March-July

Particular	Selling Rate /kg (in ₹)
PP colour	58
PP white	58
PP Natural	73
HDPE Blue	60
HDPE White	60
HDPE Natural	69



White PP



Coloured PP



Blue PP

3. RECYCLING OPERATIONS

3.1 Core Processes

This section describes the core processes undertaken at the recycling unit—sorting, grinding, washing, mixing, and extrusion. For each stage, it outlines the inputs, process steps, operational constraints, costs, rejection rates, and deviations from standard market practice. Together, these details provide a comprehensive picture of how post-consumer plastic waste is transformed into recycled granules within the unit, and the key factors that differentiate compliant operations from typical informal market practices.



1. SORTING



Input: Mixed *Fuga*

Process: Secondary sorting into ~20 categories, primarily segregating HDPE and PP by colour. Other polymers and multi-material composites are stockpiled for redirection to specialised recyclers. Sorting is conducted manually by eight designated female sorters.

Constraints: Material heterogeneity, which results in poor sorting efficiency.

Costs: Eight sorters process 110–120 kg/person per 8-hour shift, at an average cost of ₹5.2/kg

Rejects: On average, around 10% of the input is rejected as non-recyclable. Rejects include inert dust, multi-material items, contaminated packaging, laminated strips, and liquid contaminants like residual oil, shampoo, and powder (chemical wastes require specialized disposal methods to maintain quality standards for downstream processing).

Standard market practice: Pre-segregated, mono-material streams tailored to processing capabilities, optimized for throughput and material purity at the point of procurement, reduced logistical and operational complexity of manually or semi-mechanically sorting mixed polymer fractions.

2. FLAKING



Input: Pre-sorted plastic fractions (HDPE, PP, and other polymers).

Process: Batch-wise size reduction into uniform flakes using a 15 HP industrial granulator. This increases surface area, enabling more efficient washing and higher extrusion quality.

Constraints: Output depends on feeding consistency, blade sharpness, and material type. Manual feeding limits scalability and creates ergonomic strain for workers.

Costs: Approximately 800 kg processed per 8-hour shift with a 3-person team, at an average cost of ₹2.3/kg.

Rejects: Minimal direct rejects at this stage, but dull blades and inconsistent feeding lead to size variability and downstream inefficiencies.

Standard market practice: Smaller facilities, with processing capacities of 40–50 MT/month, rely on manual granulation as the standard; mechanised chipping is typically adopted only in larger operations.

3. WASHING



Input: Ground plastic flakes from chipping.

Process: Multi-stage hot washing with caustic soda and industrial detergents, calibrated to contamination levels. Cleaner materials require 2 cycles (15 min each), heavily contaminated plastics require up to 3. This is followed by density separation in a water tank (low-density polymers float, high-density/additive-rich flakes sink).

Constraints: High contamination (labels, adhesives, food residues, dirt) necessitates multiple cycles. Efficiency depends on detergent strength and agitation quality.

Costs: A 2-member team processes approximately 800 kg per 8-hour shift at an average cost of ₹1.94/kg¹⁶.

Rejects: Wastewater containing detergents, organics, and chemical residues. Treated through on-site ETP (filtration, coagulation, sedimentation, biological oxidation). Treated water is recirculated for washing and cooling.

Standard market practice: Typically done in static concrete tanks with basic rotors, offering limited agitation and poor contaminant removal.

THE CIRCULARITY–QUALITY TRADEOFF

Density separation highlights a fundamental tension in plastic recycling: maximizing material quality versus achieving complete circularity. Higher-density fractions containing additives like fillers and flame retardants can technically be processed, but compromise the thermal and chemical properties of recycled granules. While some facilities mix 3-5% of these materials into extrusion to reduce costs, this practice degrades product quality and limits end-user acceptance. The result is a trade-off where maintaining recycled plastic quality requires diverting significant material flows away from circular pathways toward energy recovery, undermining the broader goal of plastic circularity.



¹⁶Split between ₹1.50 for labour and ₹0.44 for materials (100 gm of caustic soda and detergent required per 40 kg batch)

4. MIXING (COMPOUNDING)



Input: Washed and dried plastic flakes.

Process: Thermal drying followed by pigment blending in a high-shear mixer. Colorants ensure consistency despite source variability.

Constraints: Moisture removal is essential to avoid extrusion defects. Pigments increase costs and introduce non-polymeric substances that reduce recyclability.

Costs: One worker processes a batch of 120 kg in an hour at an average cost of ₹1.32/kg for coloured flakes and ₹0.69 for black flakes¹⁷.

Rejects: Over-pigmented or unevenly dried batches risk extrusion failure and quality downgrade.

Standard market practice: Informal recyclers incorporate low-grade fillers (e.g., 2-3% calcium carbonate, talc) to increase density and reduce input costs. This lowers the material's tensile strength and impact resistance— limiting application to low-value products.

¹⁷A 40–50 kg batch requires 30–50 g pigment. Pigment prices: ₹650–750/kg (bright colors higher), carbon black ~₹65/kg, optical brighteners ₹1400–1500/kg.

5. EXTRUSION



Input: Homogenised, washed, and blended flakes.

Process: Flakes melted in a heated barrel and extruded through a 100 mm screw extruder at 70% efficiency. Fine filtration removes residual contaminants; filters clog frequently in contaminated streams, requiring replacement.

Constraints: Filter changes generate ~3% molten polymer waste. Throughput varies with contamination levels and mesh quality.

Costs: The extruder has a capacity of 120–150 kg/hour, with its effective output being 80–90 kg/hour. A 3-person team produces around 800 kg per 8-hour shift. Operating costs amount to ₹2.3/kg.

Rejects: Residues from clogged filters (~3% of output). Informal recyclers often landfill or burn this material, while our facility safely disposes it off.

Standard market practice: Informal units typically operate without PPE or fume controls, exposing workers and the environment to toxic emissions.

3.2 Compliance Challenges

Following the installation of core infrastructure and commissioning of the Effluent Treatment Plant (ETP), a formal application for Consent to Establish (CTE) was submitted to the Maharashtra Pollution Control Board (MPCB). As per regulatory norms, possession of the site and full commissioning of infrastructure were prerequisites for initiating the online application. The process required submission of detailed documentation, including lease agreements, production capacity specifications, ETP design and capacity, water usage and discharge data, and waste management plans.

Despite compliance with submission requirements, the facility remained non-operational for approximately 10 months, pending regulatory clearance. During this period, commercial operations were suspended, but controlled dry and wet trial runs were periodically conducted to maintain equipment integrity, prevent corrosion, and ensure readiness of critical machinery and support systems.

Upon receipt of the Consent to Establish (CTE), an application for Consent to Operate (CTO) was submitted with the support of a regulatory consulting agency. The approval process required an additional four months, following which the requisite license was granted.

EPR Registration Constraints

Following the receipt of the CTE and CTO, efforts were initiated to register the recycling unit on the Extended Producer Responsibility (EPR) portal. As per EPR norms, registration must be obtained in the name of the legal entity undertaking sales of the final recycled product, and that entity must possess valid CTE, CTO, and other statutory permissions in its name.

While Kashtakari Panchayat (KP), the lead implementing agency, held all necessary approvals—including rental agreements, machinery ownership, MPCB consents, and the Municipal Corporation's Non-Objection Certificate (NOC)- being a charitable trust, it is not legally permitted to engage in commercial sales. The sale of finished recycled products was instead routed through SWaCH Plus, a project partner eligible to hold EPR registration.

However, EPR registration in the name of SWaCH Plus required the transfer of all regulatory approvals and documentation to SWaCH Plus. This name change process proved administratively cumbersome and time-intensive. Despite multiple follow-ups, the municipal authority declined to issue a revised NOC in the name of SWaCH Plus for the notified area. As a result, the project was unable to complete the EPR registration process in the appropriate legal entity's name to date.

3.3 Costs and Viability

The unit incurs losses of ₹15.02 per kilogram, underscoring the lack of viability in operating 12 hours per day across two shifts, while fully complying with labor and regulatory requirements. This lack of viability reflects issues both in aggregation and in recycling. Table 2 presents the per-kilogram costs and rejection rates incurred at each stage of processing, from aggregation to recycling.

Table 2: Stage-Wise Processing Costs and Rejections

Process	₹/Kg	Rejection losses in %
Material purchase	33.0	
Transport cost (raw material/ granules/ rejects)	1.5	
Sorting	5.2	9.91%
Grinding	2.3	1.1%
Washing and Density Separation	1.5	12.8%
Extrusion	2.3	3%
Loading/ Unloading/ Stacking/ Stitching/ Space management, etc.	0.9	
Management (warehouse supervisor, project manager, accounts and finance)	7.8	
Unit overheads (electricity/ rent/ colourant/ drinking water/ tea/ repair/ security/ etc.)	23.6	
Total	₹ 78.1	27 %
Sale value/kg (for granules)	₹63.3/kg	
Viability Gap	₹14.50/kg	

Source: Data from (May/25-August'25)

To estimate the viability of industry-standard three-shift (24-hour) operations, we scaled our operational data. The costs associated with continuous 24-hour formal and compliant operations, subject to our machine capacity and operational structure are shown in Table 3.

Table 3: Industry Standard Operational Costs

Particular	₹/Kg- (24-hour operations)
Material purchase cost- including transport	48
Transport of the finished goods	0.6
Washing and Density Separation	1.5
Sorting of washed flakes	2.54
Extrusion	2.3
Loading/Unloading /Stacking/ Stitching/Space management, etc.	0.9
Management (warehouse supervisor, project manager, accounts and finance)	10
Unit overheads (electricity/rental/colourant/ drinking water/tea/repair/security/etc.)	12.1
Total	₹65.3/kg
Sale Price	₹66/kg
Net Profit	₹0.7/kg

3.4 Non-Compliance as the Sectoral Norm

Even at a conservative average sale price of ₹66/kg, Table 2 shows that this model generates a small profit of ₹0.7/kg. However, it is important to recognise that while recycling-only models improve the economics of production, they do so by externalizing the costs of collection and sorting onto waste pickers, scrap shops, and aggregators who currently enable the bulk of material flows. Effectively, this means that the viability of recycling units comes directly at the cost of the viability of scrap shops and aggregators. This has a domino effect in terms of non-compliance all the way to the bottom of the pyramid and explains the pervasive informality within the sector.

Current policy, or the lack thereof, pursues formality just for the sake of it. Waste pickers and scrap shop owners operate under precarious conditions, with no formal recognition, permissions, or municipal support. They are forced to bend zoning laws and rely on unpaid family labour or informal workers without protections just to stay afloat. All the while, municipalities provide sops to large, formalised Material Recovery Facilities (MRFs), which often receive free land, tipping fees, bonus payments, and direct deliveries of material at no cost.

Such a trajectory risks hollowing out the base of the sector. Unless corrective policy instruments are put in place, efficiency gains at the plant level will continue to come at the expense of livelihoods in the informal chain. The challenge, therefore, is not just about making recycling units financially sustainable, but about ensuring that the broader chain of collection, aggregation, and the workers embedded within it also remains viable.

3.5 Future Plans

The initial post-project transition plan envisioned transferring the operational and managerial responsibilities of the recycling unit to the waste picker group, thereby promoting ownership and long-term sustainability. This, however, proved unviable due to operational realities. An alternative proposal involved second-generation waste pickers, who are currently managing the unit, taking over ownership under a profit-sharing arrangement with waste picker workers. Despite initial interest, this idea too was shuttered due to financial risk exposure, the technical complexity of operations, and inconsistent revenue streams.

In light of these constraints, the revised strategy is to relocate the recycling unit to a government-owned facility, repositioning it as a model Plastic waste management center and knowledge dissemination center. This shift will enable the unit to function as a live demonstration site for plastic waste processing technologies and systems, accessible to citizens, educational institutions, and stakeholders for training, awareness, and capacity-building purposes.

4. KEY LEARNINGS FROM THE PROJECT

Project Protoprint was designed to incubate a compliant, clean, and green recycling facility and hand it over to an appropriate form of waste picker association, managed on cooperative principles. Operational realities posed significant barriers to this transition. The operations of the unit involve substantial technical know-how and large working capital flows, with a monthly expenditure exceeding ₹20–25 lakhs to process 25–30 MT of plastic. The overall financial viability of these operations is also uncertain due to high fixed costs, unstable market linkages, and the constant need to meet stringent product quality standards.

These roadblocks have enabled both a deeper understanding of the sector from an operational perspective as well as useful insights into how broader structural and policy-level dynamics affect the sector. The following key learnings with critical implications for both policy and practice have emerged:

1 Aggregation and Recycling Must Remain Distinct

The combination of aggregation and recycling proved commercially unsustainable. Recycling enterprises require material specialisation and process optimisation as well as policy and fiscal support. Equally aggregation functions must be supported separately with appropriate policy, infrastructure, and incentives.

2 Material Design is a Bottleneck

Approximately one-quarter of inputs were unrecyclable due to additives, laminates, or heterogeneous material composition. This raised rejection rates and labour intensity while undermining throughput. Circularity at scale will remain unattainable without upstream interventions mandating recyclable, monomaterial packaging.

3 Financial Viability Requires Structural Support

Compliant recycling operations incur costs that exceed current market sale values by a significant margin. The ₹15/kg viability gap demonstrated that compliance cannot be sustained by operators alone and requires external financial instruments—such as EPR, differential GST, or targeted subsidies—to close the gap.

4 Compliance is a First-Mover Disadvantage

While the project adhered to labour and environmental norms, competitors operating informally remained more profitable by externalising costs. This creates a perverse incentive where early compliance reduces competitiveness, thereby deterring inclusive or community-led ventures.

5 Market Exclusion by Multinational Procurement Systems

Securing partnerships with large buyers is assumed to be a pathway to stability. However, multinational procurement frameworks are structured to exclude small and mid-scale recyclers. Procurement contracts increasingly require high-volume, mono-material inputs with strict traceability and resin-specific purity standards

that community-led units struggle to deliver consistently. Even where formal labour and environmental standards are met, exclusion persists due to capacity constraints and heterogeneous input streams. Qualifying as suppliers requires heavy investment in advanced sorting, testing, and quality-control infrastructure—costs that are prohibitive for decentralised recyclers. The result is a two-tiered market: large, vertically integrated recyclers capturing high-value corporate demand, with small actors confined to low-margin buyers and volatile local markets.

RECYCLING SECTOR TYPOLOGY

The three prevalent models that characterize the sector today highlight the distinct trade-offs each carries for scale, quality, and inclusivity:

High-Volume, Low-Quality Informal Operations

Much of India's recycling sector remains dominated by informal enterprises running 24-hour operations on single material streams. Their economics rely on volume, not compliance: workers are often housed on-site, compensated below statutory minimum wages, and denied protective equipment or safe working conditions. Environmental standards, too, are severely compromised. These businesses sustain profitability by maintaining high throughput at slim margins, at the cost of labor exploitation, environmental degradation, and chronic regulatory non-compliance.

High-Quality, Vertically Integrated Models

Formal enterprises, often backed by CSR funding, impact investors, or public-private partnerships, have entered the sector in recent years. These players focus on high-value, resin-coded plastics such as PET, HDPE, and PP. This “cream-skimming” strategy leaves multi-layered, low-value plastics to smaller operators, who lack the technology and capital to process them efficiently. While these formal recyclers deliver compliance and meet brand procurement needs, they fragment the recycling pyramid and undermine the goal of the circular economy to valorize the full spectrum of plastic waste. Without an overhaul in procurement rules or incentives, such models will create and reinforce inequality in the value chain.

Brand-Led In-House Recycling

A third model is led by multinational brands, sourcing high-quality post-consumer plastics in raw form and processing them in-house. By retaining compounding, pelletizing, and extrusion within their facilities, they preserve quality control and compliance. However, this practice excludes small and medium recyclers who cannot meet the required volumes, traceability, or certification standards. Vertical integration concentrates value within corporate supply chains, further marginalizing decentralized players and deepening systemic fragmentation. The potential for cleaning recycling processes if brands are willing to run compliant operations and ensure payment of fair prices across the value chain, is high. However, the sustainability of these ventures as well as the additional burden of the cost of compliance that may be pushed on to consumers are questions that remain to be addressed.

5. POLICY RECOMMENDATIONS

The role of policy to make recycling economically viable without compromising labour welfare or environmental standards cannot be overemphasised. It is critical that the policy framework address material design, compliance, and demand creation, while also holding plastic producers accountable for the life-cycle impacts of plastics and encouraging consumers to shift behaviours through transparent information and incentives.

5.1 Material Design

- Mandate limits on non-essential and toxic additives that reduce recyclability or pose occupational health hazards with clear thresholds for safe use.
- Standardize packaging composition and regulate filler use (like CaCO₃) to prevent the production of low-quality recycle and increase process efficiency.
- Incentivize monomaterial, design-integrated packaging through tax breaks and other policy instruments to encourage producers to shift towards single-resin packaging with recyclable inks, adhesives, and labels.
- Discourage lightweighting practices that undermine recovery.

5.2 Enabling Compliance

- **EPR Financing**
 - Simplify the EPR registration process.
 - Calibrate EPR pricing to reflect the real cost of compliant recycling—including fair wages, safe working conditions, compliant logistics, and regulatory costs— for both high-value and difficult-to-recycle plastics
 - Hold plastic producers directly accountable and develop instruments that ensure that they bear the financing responsibility, particularly for difficult-to-recycle plastics, with penalties for non-compliance.
- **Tax Reform**
 - Reduce GST on small-scale waste management and recycling enterprises from 18% to 5%, or extend composition schemes.
 - Lower GST or provide exemptions for products with >20% recycled content.
- **Land Zoning and infrastructure support**
 - Allocate dedicated spaces within neighbourhoods for scrap shops and waste pickers to expand their sorting and storage capacities, improving material recovery rates and overall system efficiency, within Urban planning frameworks.
 - Notify dedicated recycling zones in urban master plans and zonal frameworks.
 - Provide adequate power, potable water, drainage, and CETP-linked effluent systems.

- **Environmental Clearances**
 - Simplify CTE/CTO procedures with approvals based on project proposals and layouts.
 - Strengthen enforcement against non-functional effluent systems in nominally “formal” units.
- **Inclusive Practices**
 - Introduce appropriate fiscal and policy support to encourage SHG/cooperative-led enterprises to establish and operate compliant, formal recycling units.
- **Knowledge Building**
 - Develop national-level training curricula on post-consumer recycling.
 - Integrate recycling-focused courses into institutions such as CIPET and expand technical education pathways.

5.3 Demand Creation

- Use fiscal incentives (GST reductions, exemptions) to drive adoption of recycled content.
 - Create regulatory mandates for minimum recycled content in plastic products.
 - Support market mechanisms that stabilize recyclate prices and reduce volatility.
 - Empower consumers to make informed choices by mandating labelling on plastic products that discloses recycled content and recyclability.
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