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RESEARCH ARTICLE

Improvising Circularity: Frugal Innovation and Informal Resource-Recovery Cycles in Pakistan

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Abstract

This study examines how informal recycling intermediaries shape circular material flows through frugal innovation, using the Recursive Resource-Recovery Cycles (3RCs) framework. An inductive grounded theory methodology was applied through two waves of data collection, comprising four pilot interviews and 22 semi-structured interviews in the main stage with actors across six recyclable streams in Pakistan: e-waste, construction and demolition debris, textiles, agricultural waste, plastics, and religious festival waste. The results reveal interconnected networks of waste pickers, aggregators, and stockpile agents who generate value through adaptive practices such as shared transport, manual repair, and improvised upcycling and downcycling. For example, pre-used hybrid vehicles are partially dismantled to exploit tax exemptions and recover residual value. Across streams, a “bag-in-bag” collection method enables progressively higher layered inventories through repeated sorting and bundling cycles. At the same time, intermediaries consolidate loads to lower logistics costs and sustain market access. However, limited traceability, due to neglected resin codes and cash-based transactions, often leads to downcycling. The 3RC framework highlights how improvisation, human agency, and material constraints drive circularity in resource constrained environments through stop gap jugaad innovation arrangements, while pointing to the need for safer technology transfer and supportive formalization.

Keywords Frugal · Jugaad Innovation · Informal Recycling · Valorization · Grounded Theory · Resource Recovery Cycles

1. Introduction

Global waste management is often framed as a contrast between technological intensity and informal ingenuity. While many high income countries rely on capital-intensive and centralized waste management systems, many Global South contexts, including Pakistan—depend on a highly decentralized informal recycling networks (Albert, 2019). In these settings, resource scarcity has fostered thrift-based innovation, commonly called “*jugaad*”, a form of adaptive creativity characterized by low-cost, improvisational solutions (Ananthram & Chan, 2021).

Addressing anthropogenic environmental crises requires a synergistic balance between how sophisticated high-tech systems and frugal, high-ingenuity practices can jointly support circularity. Throughout this study, *jugaad* is used interchangeably with "frugal innovation" to describe the capacity for to create value under conditions of constraint. While conventional Western approaches to waste management emphasize Material Flow Analysis (MFA), they often overlook the "recursive" character of informal recursive cycles, in which

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materials such as textiles and e-waste are repeatedly dyed, refurbished, and repurposed. To capture these dynamics, this study introduces the Recursive Resource Recovery Cycles (3RCs) framework to document how rural, self-organized networks generate material valorization in the absence of formal state oversight.

A globally relevant understanding of circular economy transitions must therefore account not only for the structured recycling initiatives of the Global North, but also for the indispensable, though often marginalized practices of the Global South. In Pakistan, the recycling sector faces dual challenges: low formal recycling rates and widespread social stigmatization of informal recycling work (Yousafzai et al., 2020). In Pakistan, the concept of waste management is in very primitive stages, as it still operates under colonial-era laws. The limited formal recycling infrastructure exacerbates environmental pressures (Rashid et al., 2025). For instance, in 2023, Pakistani entrepreneurs imported USD 180 million worth of pre-owned apparel, and, through creative dyeing and re-dyeing processes, upcycled these textile items into exports valued at USD 266 million, demonstrating *jugaad*-based recursive, resource value recovery (Maličká, 2024). These practices are in line with the 3Rs framework (Reduce, Reuse, and Recycle) of a cleaner production (Wichai-Utcha & Chavalparit, 2019) and resonate with the Triple Bottom Line paradigm of sustainable development (Nica et al., 2025).

However, Pakistan's recycling sector faces mounting external pressures as affluent nations continue to export or "offshore" waste to the country (Shehzad et al., 2022). There is scant published material on recycling in general, and on recycling in the context of cultures in the Global South, particularly regarding informal or frugal innovation pathways that are often dismissed as rustic or unsystematic. Despite global enthusiasm for circular economy models, a fully closed-loop circular system remains elusive (Worrell & Reuter, 2014).

The informal recycling sector in Pakistan—comprising waste pickers, aggregators, and stockpile agents—fills the gaps left by overburdened municipal systems. Yet, the labor is stigmatized, poorly regulated, and environmentally precarious (Iqbal et al., 2023). The carbon footprint of Pakistan accounts for less than 1% of the total greenhouse gas emissions (Michel Devadoss et al., 2021). Yet it consistently ranks among the top five most climate-vulnerable countries. Recurrent disasters, including the catastrophic 2025 cloud burst that claimed more than 200 people's lives in Malakand District (Ullah & Khan, 2025), underscore the urgency of adopting restorative environmental justice frameworks (Hamza, 2023) for the promotion of the circular economy.

Given Pakistan's large population, transboundary pollution, and export-driven production of goods consumed in the Global North, there is a compelling need for integrative research that links informal recycling systems, climate vulnerability, and global sustainability. This study contributes to that effort by examining indigenous *jugaad*-based recycling systems in rural Pakistan through the lens of frugal innovation theory.

Frugal innovation idea was popularized by C. K. Prahalad in his groundbreaking book *"The Fortune at the Bottom of the Pyramid,"* arguing for creating affordable yet good-grade solutions to serve the bottom of the pyramid (Prahalad, 2008). Likewise, Radjou, Prabhu, and Ahuja further popularized the idea of frugal innovation with a value proposition for doing more with less under severe resource constraints as a driver for creativity and efficiency, while reducing waste, simplifying business processes, and redefining business models (Tanguy et al., 2023). The frugalist concept appeals more to Global South countries like Pakistan, where an overwhelming majority of the population lives below the poverty lines (Ghaffar & Batool, 2025) operate under resource constraints, yet entrepreneurial agency works in unexpected ways to create more value amidst little on-hand resources. Prior studies on MSW management in Pakistan and similar contexts primarily used Material flow analysis (MFA), cost-benefit analysis (CBA), life cycle assessment (LCA), or value chain assessment (VCA) (Shaikh et al., 2020; Yi et al., 2019). This study offers fresh insights by using a *frugal innovation* process, specifically precycling, upcycling, and downcycling, as they occur in resource-constrained rural areas.

In the local dialect, the term "*jugaad*" practice is a generic term. In the context of the study, it refers to the upcycling and downcycling of recyclables for resource recovery, a practice whose sheer volume has elevated it to the status of an informal industry. The term embodies a mindset of improvisation and a mentality characteristic of quick-fix hacks, referring to the creative use of available resources to devise cost-effective solutions in resource-constrained environments (Ananthram & Chan, 2021). In essence, *jugaad* mentality represents a resourceful approach to repurpose available materials to devise low-cost, ad hoc solutions that often yield products of modest quality. This adaptive strategy is prevalent among informal recycling intermediaries—such as waste pickers, bulking agents, and stockpile dealers—operating within the resource-constrained context of District Malakand, Pakistan.

Recycling, broadly defined, encompasses a continuum of practices, pre-cycling, upcycling, and downcycling, that collectively facilitate material valorization (Yi et al., 2019). Economic activity in urban

centers is often regarded as the primary driver of growth, overshadowing the entrepreneurial agency present in rural localities, where enterprises operate in self-organized and environmentally conscious ways (Korsgaard et al., 2025) This grounded theory study aims to document the indigenous Recursive, Resource Recovery (3RCs) practices of informal waste pickers and aggregators at the rural locality of District Malakand, and elucidate how these bottom-up systems function amid weak governance and regulatory oversight. This study addresses the following research question: *What are the frugal processes of Recursive Resource Recovery Cycles 3RCs in the informal recycling sector for waste valorization in District Malakand?*

2. Materials and Methods

2.1. Methodology

The study adopts an inductive qualitative research approach to understand how informal recycling actors construct meaning and organize practices through social interaction, rather than testing a hypothetic deductive propositions oriented towards objectivity (Braun et al., 2022). Knowledge is treated as contextual and situated within social, cultural, and environmental settings. To enhance rigor and transparency, we followed the principles outlined in the *Standards for Reporting Qualitative Research* (SRQR) and the *Consolidated Criteria for Reporting Qualitative Research* (COREQ) (O'Brien et al., 2014), and used Grounded Theory (GT) as the principal analytic strategy (O'Brien et al., 2014). GT was selected because no pre-existing grand theory adequately explained the phenomenon under study, and GT supports building a substantive theory directly from empirical, context-specific data (Braun & Clarke, 2021). Accordingly, the design was emergent and inductive, allowing iterative negotiation of meaning between researchers and participants, and enabling analytic concepts to evolve during data collection and analysis. This approach generates explanations, patterns, and concepts that emerge from participants' lived experiences and perspectives, rather than imposing external theoretical frameworks.

Consequently, this study employed an emergent and inductive design, allowing iterative negotiation of meaning between the researcher and participants (Creswell & Creswell, 2017). Given the locally embedded and tacit nature of knowledge, we also attended to narrative forms and contextual clues (silences, pauses, and humor) to support interpretive depth and credibility (Tracy, 2010). Trustworthiness (Lincoln & Guba, 1985) was strengthened through SRQR/COREQ-aligned procedures, including member checks and participant debriefing, as well as ongoing memoing and reflexive analysis (Figure 2).

2.2. Study Area

The study was conducted in District Malakand, which is part of Malakand Division of Khyber Pakhtunkhwa (KP) Province, Pakistan. KP is administratively divided into seven divisions, 38 districts, 139 tehsils, and more than 1,000 union councils (Figure 1). Malakand District lies between Swat District (east), Lower Dir (north), Mardan (southeast), and Mohmand and Bajaur (west) (Ahmad et al., 2022). Data were collected from two union councils in Tehsil Thana and Tehsil Batkhela.

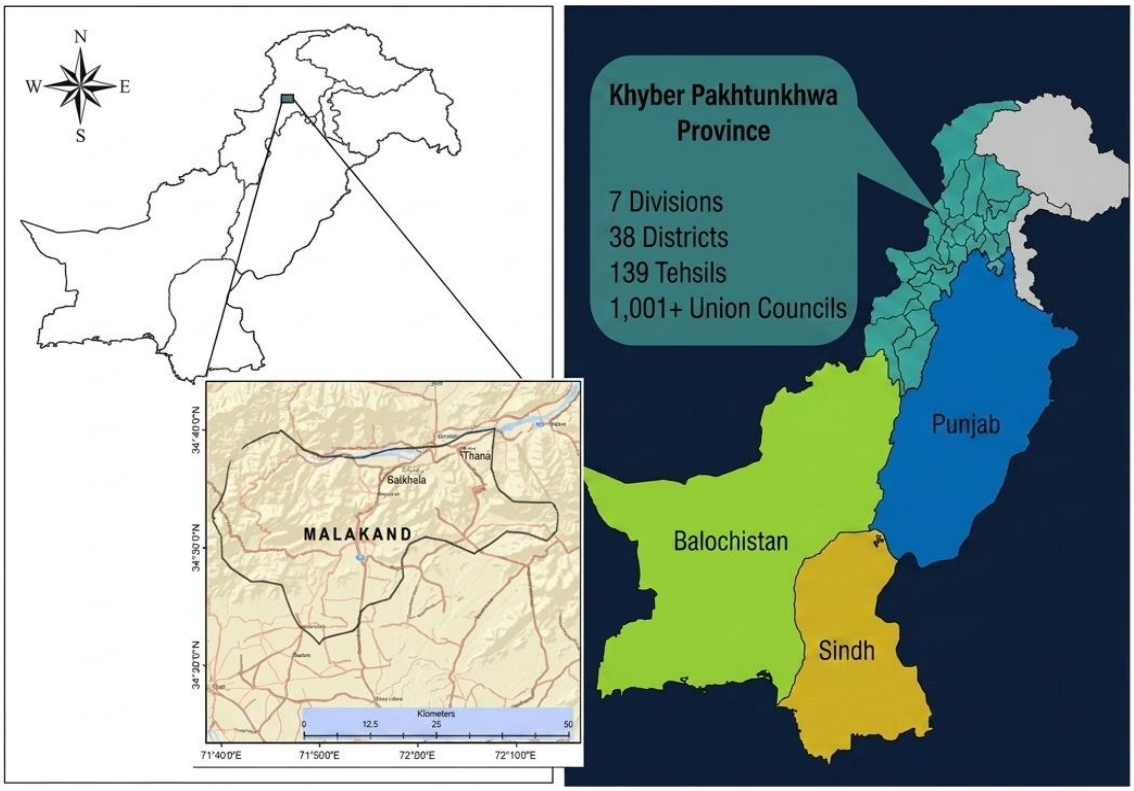

Figure 1. Maps of Pakistan and District Malakand showing the Target areas of Thana and Batkhela. (Source: Maps created using ArcGIS 10.5)

2.3. Data

Data were collected between 2024 and 2025 as part of a researcher-led field study in the tehsils of Thana and Batkhela, building on earlier work conducted in other KP districts (Nawaz et al., 2021) (Yousafzai et al., 2020). District Malakand is an income-tax-exempt district in which many small and medium enterprises operate informally, although indirect federal taxes still apply. Located approximately 250 km from Afghanistan, the district hosts a substantial informal recycling sector composed predominantly of male, illiterate laborers, with minimal participation by women due to entrenched patriarchal norms and socio-cultural constraints (Koca, 2022).

Before formal interviewing began, the researcher conducted multiple rapport-building visits were conducted to foster trust and familiarity among participants. Access was facilitated by local elders through a referral-based approach (Creswell, 2021). In total, 22 interviews were conducted across the two union councils. These were preceded by four pilot interviews that supported iterative refinement of the interview guide and alignment of field questions with emerging categories.

2.4. Sampling Procedure

In inductive qualitative research, sample size is not determined solely in advance because data collection is guided by emerging insights rather than fixed numerical targets. Grounded Theory (GT) relies on constant comparison, in which data collection, coding, and analysis proceed concurrently through an iterative, multi-stage process (Mohajan & Mohajan, 2022).

Published guidance suggest that theoretical saturation in GT commonly occurs between 9–17 interviews (Hennink and Kaiser, 2022), though other guidance places it around 20–30, depending on data richness and analytic goals (Creswell & Creswell, 2017). In the present study, saturation began to emerge during the 20th main-stage interview, and was confirmed through the final two interviews, resulting in a total of 22 full interviews. Including the four pilot interviews, 26 interviews were completed. The pilot interviews were used to refine the interview guide and to identify initial analytic directions. We refined the wording, sequencing,

and probes in the semi-structured guide (Table 1). Emerging categories then shaped subsequent interviews through targeted probing across actor tiers and material streams until no substantively new properties were observed. We clarified field questions to capture better recursive processes across material streams (e.g., transport coordination, sorting cycles, and downstream constraints).

We therefore report the final sample size as an outcome of theoretical sampling and saturation rather than as adherence to a pre-set numeric heuristic. Determining an appropriate sample size in GT research is a matter of tradeoffs. Too few interviews may lead to analytic foreclosure, in which emergent patterns cannot be fully developed, while too many interviews can overwhelm the analysis and obscure meaningful interpretation. In GT studies, experts use a variety of heuristics or rules of thumb for the determination of the number of interviews, such as some argue for ^{N}=20 interviews, ^{N}=20-30 interviews, and ^{N}=50 interviews, and some propose the ^{N}=12±10 interviews (Yousafzai et al., 2020). Beyond saturation, we also considered information power when finalizing sample size, evaluating dataset adequacy in relation to aim, specificity, theoretical grounding, quality of dialogue, and analytic strategy (Malterud et al., 2016). By integrating both theoretical saturation and information power, the study ensured that the sample was sufficiently large to capture diverse perspectives, while remaining feasible for rigorous qualitative analysis.

GT analysis proceeded through open, axial, and selective coding, with constant comparison and iterative codebook refinement to accommodate emergent categories (Fig 2). As shown in Figure 2, GT can be implemented through two commonly cited approaches. While both share the core principles of theoretical sampling, constant comparison, and theoretical saturation, the Straussian approach is generally more structured (Corbin, 2017). We employed a Straussian GT approach. Consistent with the Straussian GT pathway depicted in Figure 2, analysis proceeded through open, axial, and selective coding, supported throughout by constant comparison, memoing, and iterative codebook refinement. Early codes and emerging categories from the pilot interviews informed revisions to the interview guide. They guided theoretical sampling and probing during the mainstage interviews, continuing until theoretical saturation was reached.

To make the analytic progression transparent, we provide an illustrative example of how one excerpt moved through coding stages. In open coding, a participant described: 'we put bags inside bigger bags so we can sort again later and carry everything together' (plastic-stream intermediary). This excerpt was initially coded as *bag-in-bag bundling*, *layered storage*, and *re-sorting for transport*. During axial coding, these codes were linked with other transport-related codes (e.g., consolidation and partial-load constraints) into a higher-order category: *logistics-enabling improvisation under scarcity*. In selective coding, this category was integrated with related categories (e.g., *tiered consolidation*, *inventory build-up before dispatch*, *limited traceability*) to support the core explanatory concept that 3RCs are sustained by recursive consolidation and refinement cycles that substitute for missing formal infrastructure but can also reproduce downcycling and risk.

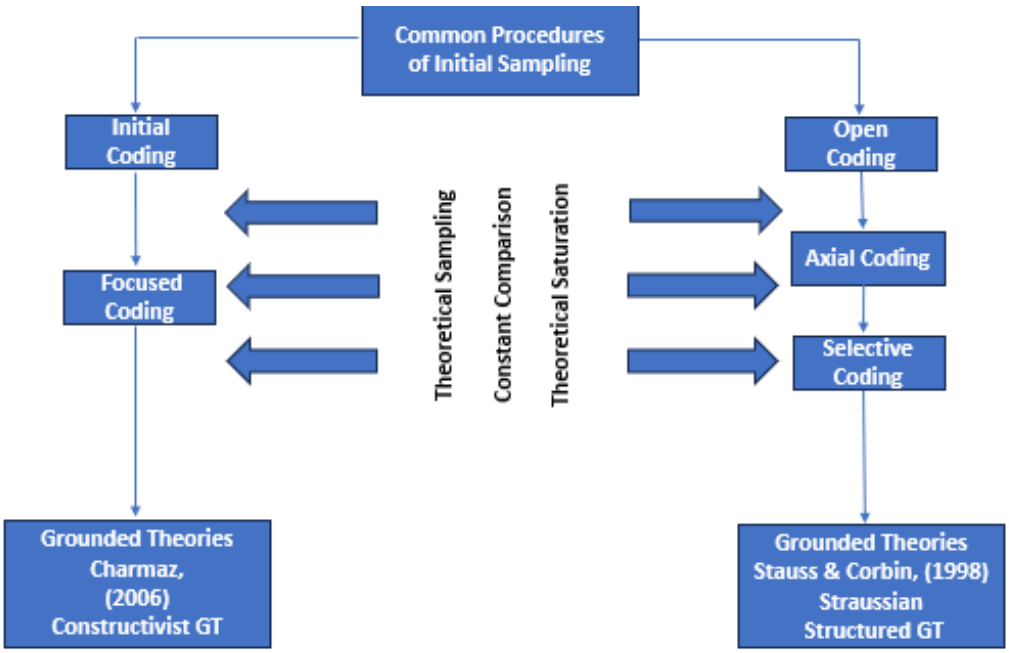

Figure 2. Coding processes in a condensed and full grounded theory design (Source: adapted from Thornberg 2017).

2.5. Interview Guide and Ethical Protocol

The semi-structured interview guide (Table 1) was iteratively refined during the pilot phase to enhance clarity and cultural relevance (Majid et al., 2017). Ethical approval for the study was granted in 2024 by the Office of Research Innovation and Commercialization ORIC, University of Swat in 2024. Informed consent was collected from participants before the interviews.

Because some participants had limited literacy, consent procedures were adapted to the local context. In such cases, verbal informed consent was obtained through proxy indicators, such as collecting CNIC (Computerized National Identity Card) numbers containing biometric data and mobile phone numbers in the presence of an eyewitness. No identifying documents were retained, and any optional contact information provided for scheduling or follow-up purposes was not included in the analytic dataset.

All interviews were done in the local language, respecting regional customs and ensuring a non-judgmental and participatory interactional space (Dutta, 2019). Rapport was established through repeated workplace visits before formal data collection (Nawaz et al., 2021). The participants were given aliases to protect privacy, and confidentiality (Coomber, 2002).

The researcher's positionality and reflexivity were also documented at the outset, and a structured observational protocol supported memoing and reflexive analysis throughout. In addition to spoken responses, attention was paid to tacit and contextual features of interaction, including silences, pauses, nods, and humor, to strengthen interpretive depth and credibility (Tracy, 2010).

Table 1. Extracts from the interview guide used

Section	No.	Interview Main Questions
Introduction	1.	General ice breakers, backgrounds, mini tour, grand tour, and taxonomic questions
General Practices	2.	What type of recyclable materials do you collect regularly?
Transportation	3.	What difficulties do you face in transporting recyclables to downstream centers?
Textile Waste	4.	What is done with used clothes, fabric scraps, or textile waste?
Plastic Waste	5.	How is plastic waste (bottles, bags, packaging) collected and sorted?
E-Waste	6.	How do you handle waste electrical and electronic equipment WEEEs?
C&D Waste	7.	How do you recover C&D waste from mining, quarrying, and extractive industries?
Organic waste	8.	How do you handle the organic waste generated during Eid Al Azha?
Agriculture Waste	9.	How do you handle leftover crop material, husk, or animal waste?
Eid Al Azha Waste	10.	How is waste generated by the Feast of Sacrifice handled?
Closing Question	11.	Are there any other frugal ways of recycling you would like to share?

2.6. Data analysis with Grounded Theory (GT)

To ensure analytic rigor, the study combined general qualitative data management procedures with the specific analytic steps of GT. Interview transcripts were first prepared through systematic data curation and organization before coding began (Lungu, 2022). The code book was developed iteratively to accommodate emergent categories, expected, unexpected, and conceptual codes (Khalid et al., 2025).

Coding involved organizing the data into meaningful segments and assigning interpretive labels to these segments (Mohajan & Mohajan, 2022). Consistent with the Straussian GT approach adopted in this study, analysis proceeded through three stages: open coding, axial coding, and selective coding (Figure 3) (Qureshi & Ünlü, 2020). In open coding, all relevant data segments were examined without exclusion to identify initial concepts and categories. In axial coding, relationships among categories were explored by linking phenomena, conditions, actions, interactions, and consequences. In selective coding, the major categories were integrated into a coherent explanatory framework that captured the central patterns emerging from the data (Mohajan & Mohajan, 2022).

The concept of theoretical sampling in GT entails that data collection and analysis are undertaken simultaneously (Creswell, 2021). In this study, ongoing analysis informed subsequent probing, refinement of categories, and interpretation of emerging patterns. This iterative process supported the development of a substantive theory grounded in participants' lived experiences and everyday recycling practices.

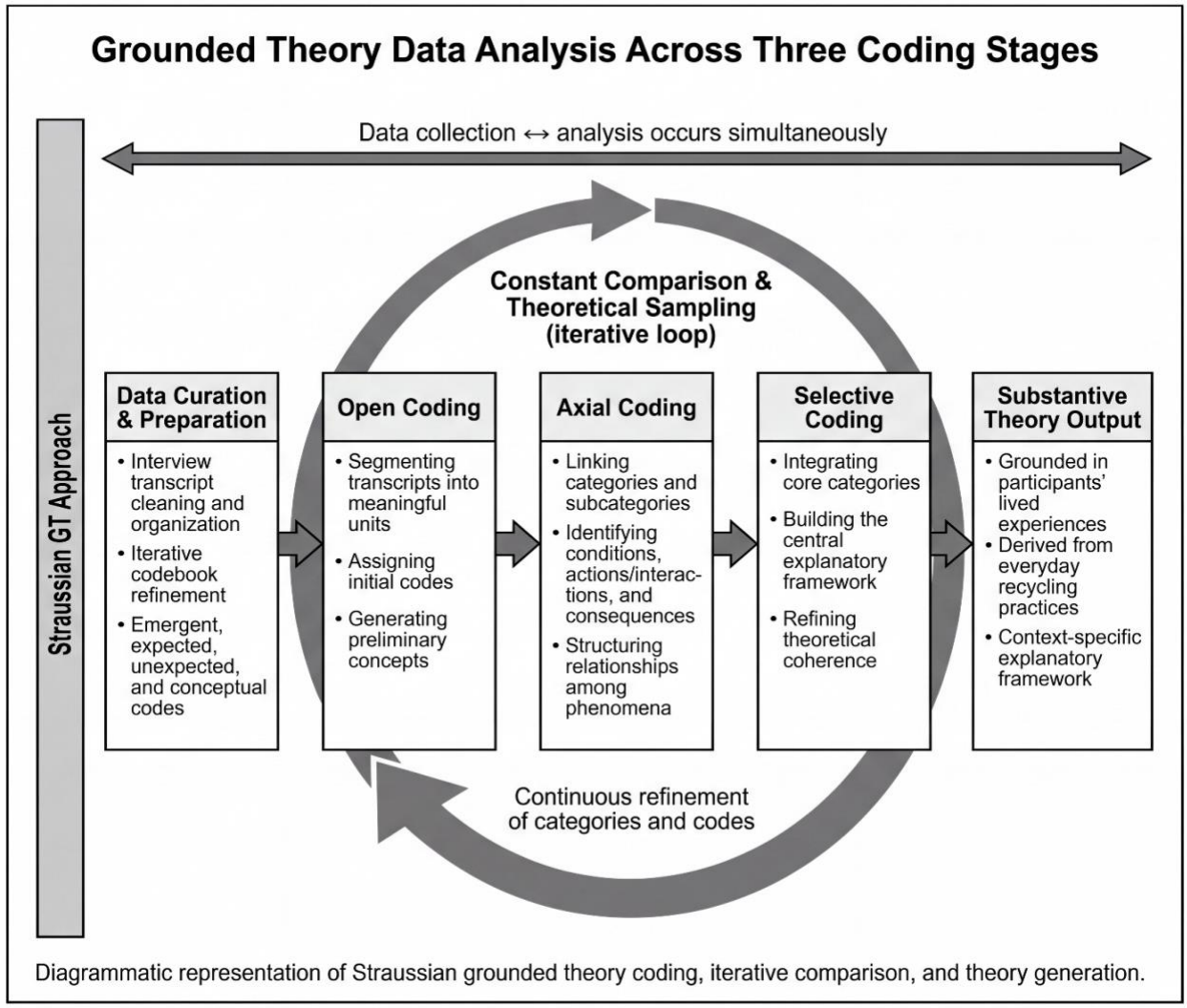

Figure 3. Diagrammatic representation of grounded theory stages across three coding stages (adapted from Tariq, 2018, and generated using NanoBanana)

3. Results

The three sequential stages of GT coding—open, axial, and selective—were applied to the interview data to elucidate patterns of informal recycling practices and Recursive Resource Recovery Cycles (3RCs) in District Malakand. This analysis illuminates a complex, community-driven system of frugal innovation in a resource-constrained setting, where local actors optimize material flows within informal economies to generate both economic and ecological value.

3.1. Recyclable Materials Handled by Informal Intermediaries

The first issue explored in the interviews was: "What type of materials are collected by informal recycling intermediaries for using recursive waste resource recovery cycles?"

The initial analysis examined the types of materials collected by informal intermediaries. The findings indicate that many intermediaries are internally displaced persons or migrants from districts bordering Afghanistan, who engage in recycling discreetly to navigate the social stigma associated with their work.

Open coding identified six primary categories of recyclables: post-consumer plastics, construction and demolition (C&D) waste, electronic waste (e-waste), textile waste, agricultural residues, and sacred organic waste from the Eid al-Azha feast of sacrifice. Axial coding further revealed specialized low-volume streams,

including institutional waste, mechanical waste, virgin materials, and medical waste. Selective coding confirmed that the most significant recycling activity centers around C&D waste, e-waste, textile waste, agricultural and organic waste associated with the Eid al-Azha feast of sacrifice, and post-consumer plastics.

These findings reveal a sophisticated system of frugal, community-based resource recovery consistent with the ethos of *jugaad* innovation, whereby local actors creatively repurpose discarded materials through pre-cycling, upcycling, and downcycling. Recyclable composition estimates indicate that 30% is plastics and PET bottles, 30% is cardboard and carton packaging, 20% is construction and demolition (C&D) waste, and 20% is miscellaneous materials, typically compacted into pallets for transport to downstream recycling hubs. Table 2 summarizes the recursive resource recovery processes (3RCs) and their estimated economic contributions.

Table 2. 3RCs-based recycling of key recyclables in the target area of study.

Primary Waste Type	Subcategory / Source	Secondary Process (RRC1)	Tertiary Process (RRC2-RRCn)	Estimated Value (USD)	Key Outputs / Products	Environmental / Social Notes
E-Waste	Obsolete electronics, cut & shut cars, laptops, cellphones	Magnet-cycling, spare parts extraction, sensors, switches, fuses	Metal extraction (Cu, Au, Al), refurbishment of printers/copiers, nuts/bolts recovery	20,000,000	Recovered metals, refurbished electronics	Toxic exposure risk, high informal labor participation
Eid al-Azha Feast of Sacrifice Waste	Hides, bones, fats	Crockery, cutlery, buttons, sticky glue & gum	Animal fat → ghee, cooking oil, poultry feed; hides → leather goods, bed ropes	1,100,000	Leather goods, glue, feed, beds	Seasonal spike, culturally significant, biohazard risk
Plastic Waste	PET bottles, packaging, plastic drums, jerry cans	Polyester clothing, woven bags, bag-in-bag collection	Plastic shoes, low-cost pipes, agriculture nets, upcycled materials	1,700,000	Shoes, pipes, netting, repurposed plastic	Urban plastic bags are partially enforced; rural waterways are clogged
Agricultural Waste	Rice husks, wheat residues, crop leftovers	Haystack fodder, bedding, composting	Biofuel, ethanol, biogas, Mazri crafts (hats, fans, mats)	400,000	Fodder, compost, biogas, artisanal crafts	Stubble burning causes seasonal air pollution
Textile Waste	Factory overruns, second-hand imports, campaign flags	Freecycling, cloth swaps, defect padding	Re-dyeing, upcycling, flea market resale, insulation, toys, upholstery	900,000	Quilts, bags, wipers, furniture padding	Low-income reuse culture: urban centers drive advanced upcycling
C&D Waste	Marble, bricks, concrete, asphalt, wood	Quarrying, extraction, and slurry repurposing	Cement, dishwashing powder, biomass fuel, fill material	25,000,000–30,000,000	Construction materials, fuel, and landscape leveling	High volume; adaptive reuse after floods/earthquakes; labor-intensive

3.2. Transportation Constraints

Participants consistently reported transportation as a major constraint in moving recyclables to downstream processing centers. Open coding revealed heavy reliance on antiquated Bedford J5 and J6 trucks, many dating from the late 1960s, which are fuel-intensive and mechanically inefficient. Local mechanics employ *Khairidi* modifications to increase load capacity from 9 to 14 tons. Although these modifications reduce per-load transport costs and improve full-truckload economies, they also increase maintenance demands and accident risk.

Axial and selective coding further showed that, in the absence of railway infrastructure in target area of study, intermediaries coordinate logistics informally. However, police weighbridge fines, road enforcement practices, and cash-based transactions increase operating costs. These constraints create upstream inventory

accumulation, as depicted in Figure 4, reflecting delays and inefficiencies in downstream logistics. This pattern resembles the bullwhip effect, in which downstream disruptions or demand shocks generate progressively larger inventory build-up at upstream stages. Figure 4 illustrates this generic pattern: recyclable materials accumulate in increasing volumes as they move from frontline waste pickers (Tier 1) to consolidators and aggregators in higher tiers (Tiers 2–4), where delays, aggregation, and stockpiling occur before final processing or export.

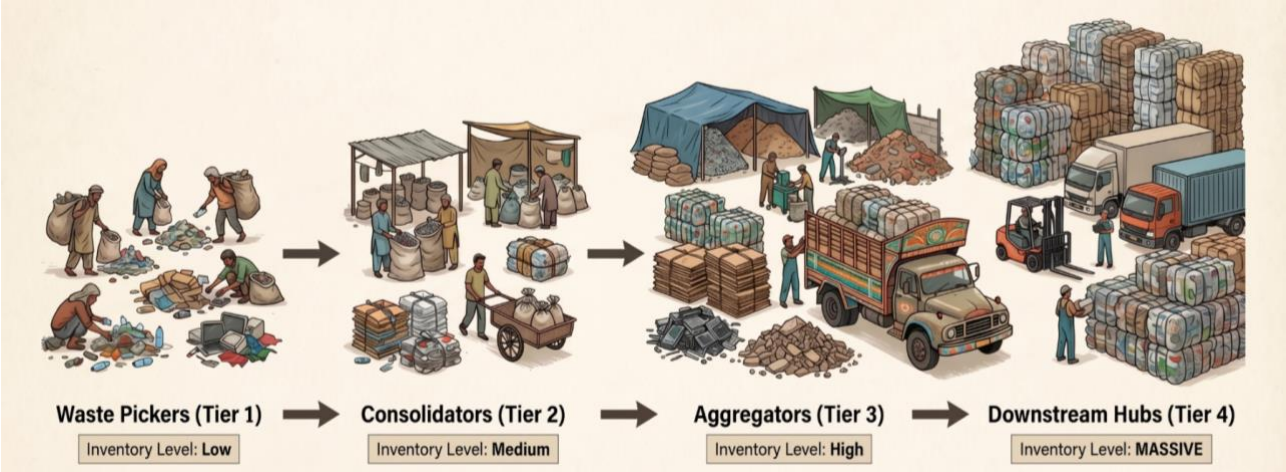

Figure 4. A generic visual representation of the distribution of inventory levels across different tiers of the informal recycling value chain for municipal solid waste (Source: Image was generated using NanoBanana)

3.3. Textile Waste 3RCs

Textile waste emerged as one of the most efficiently recycled materials, with most materials entering recursive recovery loops. High-quality garments circulates through reuse, donation, and resale, whereas low-quality textiles—such as campaign banners and flags—are more likely to be downcycled or discarded. Flea markets supply both imported second-hand clothing and local factory overruns, meeting growing demand under conditions of declining purchasing power and serving base-of-the-pyramid markets.

A central theme emerging from participants' verbatim accounts is the dynamic culture of textile reuse and repurposing within local communities. "*In addition to giveaway areas such as the wall of Kindness (free clothing swap), both upcycling and downcycling of apparel-related items occur due to an established tradition of dyeing and re-dyeing of fabric materials. The imported 2nd hand textiles and overruns from factories are sold and resold in flea markets, as well as good quality yet minor pre-consumer defective items are reused by conversion to vast-coats and upholstery furniture padding.*"

Axial coding highlighted popular 3RC practices such as fabric re-dyeing, cloth swapping, and flea-market recirculation. Selective coding indicated that textiles are repurposed into quilts, upholstery, stuffed items, wipers, bags, and mattresses, particularly in rural areas, whereas urban centers drive more advanced upcycling processes, such as denim refashioning. The popularity of imported second-hand textiles was often attributed to their perceived quality relative to locally produced alternatives.

3.4. Plastic Waste 3RCs

Plastic waste in the study area originates mainly from discarded packaging materials, PET bottles, and single-use containers. The widely adopted "bag-in-bag" collection system enhances both storage efficiency and the transport of recyclables, serving as an essential intermediary step in the local recycling chain. Recovered plastic bags and pouches are repurposed not only as collection tools but also as raw materials for the production of low-cost consumer goods, including plastic shoes and slippers, woven materials for garments and carpets, and packaging film. Field observations revealed several additional reuse pathways: sugar sacks are converted into durable mesh bags, PET bottles are repurposed as storage jars and plastic footwear, and lightweight pipes are manufactured from reclaimed plastic for use in mountain irrigation and agriculture.

A central theme emerging from participants' accounts was the adaptive ingenuity of informal recyclers who transform discarded plastics into economically valuable products. *"Plastic sacks of sugar are converted into porous plastic net sacks for plastic leno bags, Pilate wrapping net for tunnel farming agriculture. Moreover, PET bottles are upcycled to make jars, plastic footwear for the proletariat, and in the manufacture of [what do we call it? Ahaan, low-cost, brittle yet cost-effective pipes are used in high mountain water supply].*

The axial coding indicates that there are Universal recycling codes for plastics, batteries, paper, and metals (Mohamad et al., 2007). However, local knowledge of resin identification codes (RICs) remain limited, which increases workload and reduces the quality of recycling activities at downstream facilities. Despite some growing awareness of resin identification codes, most local recyclers still lack standardized classification systems. Selective coding showed that although single-use plastic bags are banned in urban areas, compliance remains limited in rural settings, where plastic waste frequently blocks tributaries and drains, especially during dry seasons.

3.5. E-Waste 3RCs

E-waste constitutes an increasingly significant stream of recyclables in the study area, primarily entering Pakistan through informal channels originating in the Middle East and surrounding tax-free zones. The WEEE refers to any appliance with an electric power supply that has attained its end-of-life (Islam & Huda, 2018)**.** District Malakand, as a designated tax-free region, serves as a focal point for the influx of used electronics, hybrid vehicles destined for Afghanistan, and refurbished equipment such as computers, cell phones, and laptops. Many of these imports, often coated with toxic flame retardants, pose significant health risks to both end users and recycling workers, despite perceptions of occupational resilience observed during fieldwork.

A central theme by way of verbatim extraction of empirical data entails,

Most of the time, ferocious metals are collected through magnetic cycling, as well as new models render old electrical and electronic items obsolete. Non ferocious items are mostly extracted by wiring experts (Cooper) Lead (batteries) Nickel (Computers) and even Gold from electric appliances is recycled through creative sifting and sorting processes and used in the manufacturing process as well as making nuts, bolts, bars, rods, and covers.

Open coding revealed a well-established ecosystem of manual refurbishment and materials recovery, focused on extracting ferrous and non-ferrous metals—including copper, nickel, lead, and gold—through techniques like magnetic cycling and expert dismantling. The rapid technological obsolescence of electrical and electronic appliances fuels the steady expansion of this market. Notably, increased energy costs have driven up the demand for improvised battery refurbishment, especially for use with inverters and solar systems, further extending the operational lifespan of downcycled e-waste components.

Axial and selective coding highlighted that, in the absence of formal electronic recycling infrastructure in rural Pakistan, manual sifting and sorting dominate. These frugal (*jugaad*) practices can increase end-of-life recycling rates but they also expose workers to hazardous emissions and environmental risks. Field evidence is consistent with Ciconkov (2018), who estimates that improper handling of refrigerant gases from discarded appliances can contribute up to 2 tons of CO_2-equivalent per kilogram released. This underscores both the ingenuity and vulnerability inherent in the informal sector's resource recovery processes.

3.6. Construction and Demolition (C&D) Wast

Recent government stimulus initiatives introduced in response to the COVID-19 economic downturn have contributed to a marked increase in construction and demolition (C&D) waste generation across Pakistan. Open coding revealed that as new buildings replace older structures to accommodate the needs of the world's fifth-most-populous country, large volumes of material are recovered and creatively repurposed. Empirical data highlight diverse applications for C&D waste: marble slurry is upcycled into dishwashing powder, lime, and Portland cement; mortar, gravel, and mine residue are used for landscape leveling and emerald stone recovery; and scrap materials are repurposed for home decorations and the production of plaster of Paris.

A central theme by way of verbatim extraction of empirical data entails,

Construction and demolition-oriented Waste recycling is useful for utilization, including marble slurry leftover utilization in dishwashing powder, lime, Portland cement, mortar gravel from crush plants, emerald

stone recovery from mine residue, and construction dumping and landscape levelling. The scrap is also used in home decorations, and making of plaster of Paris.

Axial coding indicated rising demand for affordable, alternative building materials such as checkboard, plywood, steel, aluminum, and glass, driven by escalating prices in conventional construction supplies. Simultaneously, unregulated stone quarrying and marble cutting continue unabated, further contributing to the recycled material pool, wherein marble slurry is upcycled in the form of Portland cement, dishwashing powder, and mortar lime.

Selective coding underscores that C&D waste management closely follows a law-of-conservation-of-matter paradigm, with leftover materials continuously reincorporation, with leftover materials reused in fencing, shade structures, and site leveling for new developments. Natural disasters, including the 2025 monsoon floods, have added substantial debris streams, turning destruction into resources for rebuilding bridges, roads, and houses in Malakand District. The growth of C&D recycling activities demonstrates the adaptive resilience and creativity of informal economies, while also signaling the need for safer, low-cost, and more efficient construction technologies and the transfer of innovative approaches from developed to underserved regions.

3.7. Organic Festival Waste

Seasonal events such as the Eid al-Azha generate pronounced surges in organic waste across Muslim-majority regions, with Malakand District representing a key example. Open coding revealed that putrescible livestock by-products, including hides, bones, and animal fats from ritual sacrifices, are transformed from discarded waste into valuable inputs for diverse local industries. Hides are actively collected by charitable organizations and artisans and upcycled into leather coats, purses, wallets, and traditional Peshawari footwear. Bones are processed into glue, gum, buttons, and higher-value crockery products. Residual animal fats are reused in the production of cooking oil, ghee, Vaseline, and poultry feed. While social phenomena such as “cow shaming” are increasingly visible due to digital media exposure, field data highlight the festival’s role as an economic catalyst for agropastoralists and local craftspeople.

A central theme by way of verbatim extraction of empirical data is furnished as under:

Putrescible recycling such as hide collection by Tainers and charitable organizations. Moreover, 2nd-hand leather from foreign articles is sewn into leather coats, purses, and wallets, as well as Peshawari captain chapals. The Feast of Sacrifice-related post-harvest waste is used in making pet & poultry feed, edible oil, and ghee. Other innovative usages of animal waste on sacred festive occasions include bespoke bed knitting ropes and buttons, and cutlery items, as well as glue and gums from animal bones.”

Axial coding underscores innovation and frugal ingenuity in upcycling: animal hides are used as cost-effective materials to produce bug-free woven bunk beds, and the bones are used for upscale crockery manufacturing and sticky glue production; festival waste stimulates temporary booms in associated businesses. The conversion of slaughter waste to biogas and raw materials for the regional leather industry further illustrates the versatility and economic importance of organic recycling—despite its informal, unregulated nature.

3.8. Agricultural Waste

Recursive resource recovery in agricultural waste in Malakand District is characterized by the efficient reuse and upcycling of post-harvest residues, predominantly rice husks and wheat straw (*bhusa*). Open coding revealed that these residual materials provide essential inputs for animal husbandry—serving as livestock fodder, bedding, and feed supplements—while simultaneously enabling biomass recycling.

Unlike urban contexts, where household kitchen waste is often collected to supply cattle farms (Yousafzai et al., 2020), Malakand's extensive pastures and grazing lands support free-roaming livestock managed by agropastoralists. Field data illustrate local ingenuity in the use of organic waste: crop residues and manure are used for composting, natural fertilization, and as feed, and are sold at prevailing market rates (e.g., PKR 20,000 per truckload).

A central theme emerging from participants’ accounts was the routine reuse of agricultural and livestock-related organic waste,

Agriculture and animal husbandry livestock oriented organic waste is re-used or upcycled in natural ways such as hay stacking of rice husk, thrashed leftover from wheat harvest as animal fodder, plant debris

composting and manure from animal as natural fertilizer. Other interesting low tech uses include Maziri hats, hand fans, prayer mates and extraction of biogas in certain cases.

Axial coding revealed that widespread stubble burning is a major environmental challenge in Malakand, contributing to dense winter smog and causing significant visibility and air quality issues in low-lying areas. Alhough some plant debris is recycled locally through composting, and ruminant manure is regularly sold as a fertilizer supplement (e.g., PKR 20,000 PKR per truckload), the scale of these efforts remains limited. Selective coding further illustrates that agricultural field residues serve important secondary purposes: migratory livestock herds graze on leftover stubble during winter, helping to mitigate feed shortages in upland areas. Locally available resources, such as Mazri (*Aich*) branches, are skillfully repurposed into summer hats, hand fans, threads, bedspreads, and ropes. These products have both practical and, in some cases, medicinal or aromatic uses, reflecting the integration of traditional knowledge into contemporary resource recovery practices. Although small-scale biogas extraction and composting of plant debris are evident, substantial upscaling is needed to achieve broader economic benefits and to improve the recycling of grass clippings, leaves, fruits, vegetables, and branches across the region.

3.9. Cross-stream Synthesis

Across the six recyclable streams, intermediaries do not simply hand off materials along linear chains; instead, they repeatedly consolidate, sort, and re-bundle materials across tiers, creating recursive loops that stabilize market access under uncertainty. These loops are evident across all streams—from layered storage and re-sorting in C&D waste, to resale and re-dyeing cycles in textiles, iterative dismantling in e-waste, and repeated reuse pathways in industrial, agricultural, and organic systems—highlighting circularity as a non-linear, feedback-driven process.

Three cross-cutting mechanisms structure these dynamics. First, logistics-driven consolidation organizes material flows around full truckload economies and key dispatch nodes, particularly in high-volume or seasonal systems. Second, value is incrementally extracted through repeated sorting and quality refinement across multiple actors. Third, gaps in traceability and standards, stemming from limited classification knowledge and informal transactions, often shift outcomes toward downcycling and uneven value capture.

Transport and enforcement constraints further shape these systems by generating inventory buildup and "bullwhip" effects, especially in high-volume (e.g., C&D) and high-risk (e.g., e-waste) streams, as well as during seasonal surges such as Eid al-Azha. In response, frugal innovation substitutes for formal infrastructure, with low-cost, improvised practices enabling reuse and transformation across all streams.

Finally, differences across streams are explained by material properties and risk profiles. E-waste poses acute toxicity risks; C&D waste is volume-intensive and disaster-responsive; industrial waste involves significant handling burdens; agricultural residues reflect tradeoffs between reuse and burning; and Eid al-Azha organics are highly seasonal and biohazard-sensitive. Together, these patterns show that while circular systems enhance recovery, they can also introduce environmental and health risks in the absence of safeguards.

4. Discussion

This study elucidates the structure and dynamics of informal recycling intermediary networks in District Malakand, Pakistan, through the lens of frugal (*jugaad*) innovation using an inductive grounded theory design. By generating a grounded theoretical framework, this research offers a substantive explanation of how informal waste management functions in a rural, resource-constrained setting, extending prior district-level studies by moving beyond sector-specific descriptions toward an integrated, system-level account (Khalid et al., 2025). Our bidirectional logic network framework offers a comprehensive snapshot of the RRCs in the study area, extending the conventional 3Rs (concept of Reduce, Reuse, and Recycle, (Wichai-Utcha & Chavalparit, 2019)) to capture the recursive, multi-tiered nature of resource recovery in informal waste systems in Pakistan. Importantly, the 3RCs framework is not presented as a re-labeling of linear value-chain stages; rather, it conceptualizes informal recycling as recursive cycles in which materials are repeatedly sorted, sifted, bundled, and consolidated across intermediary tiers. These cycles generate feedback effects on inventory, material quality, and downstream market access that are often obscured in linear "handoff" depictions. By foregrounding these recursive loops rather than only sequential handoffs, 3RCs make visible the mechanisms

through which circularity is achieved (and constrained) under weak infrastructure and limited formal governance.

Our findings indicate that RRCs operate bidirectionally across industrial and household sources, with parallel in upstream (industrial collection) and downstream (municipal collection) pathways and complex interactions among waste pickers, aggregators, and stockpile agents (Figure 5). In upstream pathways, waste pickers collect materials from industries and forward them to waste aggregators (RRC2), where items are consolidated and transferred to stockpile agents. These agents further sift the items and load them onto dedicated trucks for onward transport to recycling centers. This process depends on collective cooperation, because truckload consolidation is necessary for economic viability and less-than-truckload shipments reduce margins.

Across tiers, sorting, sifting, and consolidation occur iteratively and often simultaneously, allowing progressively refined materials to be transported onward for upcycling where facilities exist. As materials move from RRC1 into higher-order consolidation (RRC2 and beyond), inventory held by intermediaries increases and peaks before final dispatch to urban centers, while small-scale downstream intermediaries tend to maintain lower inventory levels due to more limited consumer-side collection. This pattern is consistent with the inventory build-up described in the manuscript and the "bullwhip effect" analogy noted for closed-loop supply chains, where downstream constraints and shocks amplify upstream stockpiling pressures. In practical terms, the framework helps explain *where* delays occur (pre-dispatch tiers), *why* they occur (truckload economics, transport constraints, enforcement/transaction costs), and *which nodes* are most amenable to policy interventions (e.g., logistics coordination, safe transport, aggregation hubs)

The analysis further clarifies why outcomes diverge between upcycling and downcycling across locations and material streams. The use of dedicated truckloads for paper, steel, and plastics reduces intermixing and supports downstream processing. However, most upcycling remains concentrated in urban recycling centers, whereas downcycling is more common in rural areas due to limited technology and infrastructure (Hees et al., 2025). Taken together, these patterns show how a resource-constrained yet self-organized system spanning precycling, upcycling, and downcycling can mitigate environmental burdens at low cost, while also revealing the structural bottlenecks (transport coordination, technology gaps, and traceability constraints) that shape circular outcomes.

In plastics specifically, the widespread "bag-in-bag" collection practice enables layered inventories and repeated bundling cycles. However, limited material traceability, driven by weak knowledge and use of resin identification codes, raises downstream sorting burdens and systematically favors lower-value downcycling over upcycling. Similarly, in the e-waste stream, reliance on manual dismantling in the absence of formal facilities constrains recycling efficiency and increases occupational hazards (including PBDE exposure and refrigerant release risks). These findings underscore that frugal innovation can raise end-of-life recovery rates while simultaneously generating environmental and health vulnerabilities when operating outside formal standards and protections.

Material composition across the RRCs consists of plastics and PET bottles (30%), cardboard and carton bulky waste, mainly comprising electronic appliance packaging (30%), construction and demolition waste (20%), and miscellaneous recyclables (20%). The six primary contributing streams, textiles, e-waste, C&D waste, Eid Al Azha animal by-products, agricultural waste, and plastics, anchor the empirical basis of the 3RCs logic network and help explain why different material streams follow different recovery trajectories under the same overarching constraints

Overall, the 3RCs framework provides a substantive explanation of how informal recycling functions as a dynamic system, characterized by repeated refinement across tiers, bidirectional flows across sources, and constraint-driven inventory and quality dynamics that shape what circularity is achievable in practice. This moves the analysis beyond a linear value-chain depiction toward a mechanism-oriented account of recursive circularity in resource-constrained contexts, small-scale, and strengthens the manuscript's contribution to circular economy research.

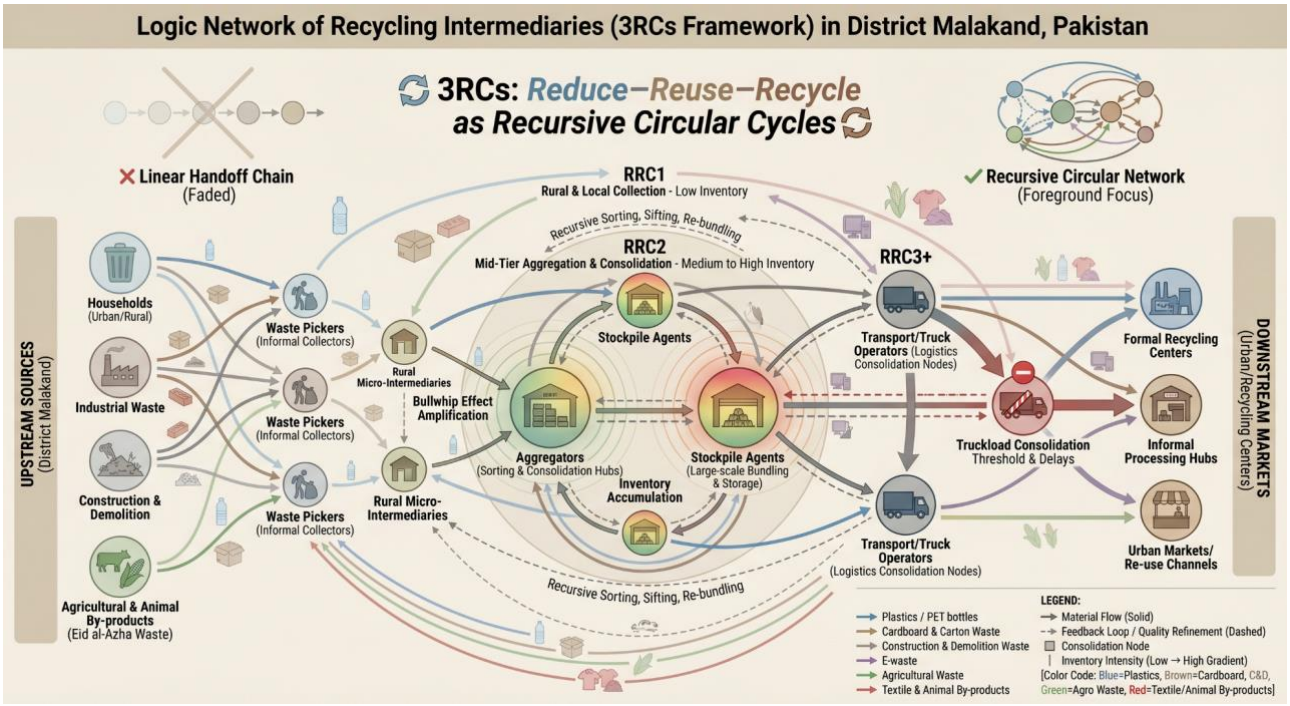

Figure 5. Logic Network of Recycling Intermediaries in District Malakand. (Source: Image was generated using NanoBanana)

4.1. Jugaad (Frugal Innovation) and Operational Constraints

In this study, we treat frugal innovation (*jugaad*) not as a generic synonym for 'informal,' but as a mechanism observable in routine waste management practices under scarcity. Empirically, a practice is coded as frugal innovation when it (i) substitutes for missing formal infrastructure or standards through low-cost improvisation, (ii) increases feasibility of material recovery or market access, and (iii) entails tradeoffs in quality, safety, or environmental performance. In Malakand, this includes repeated sifting/sorting and consolidation across tiers, low-cost logistics coordination to reach full truckloads, and improvised repair/refurbishment in streams such as plastics and e-waste. These practices increase recovery activity, but they also contribute to downcycling where traceability is limited and higher occupational exposure where formal processing is absent.

The concept of *jugaad*, understood here as low-cost, locally improvised innovations, enables intermediaries to extract value across these categories, albeit without strict adherence to formal standards such as resin identification codes (RICs). Transportation constraints, especially partial truckloads, lead to inventory buildup and delays, resembling the "bullwhip effect" observed in closed-loop supply chains (Braz et al., 2018).

Textile recycling in Pakistan highlights frugal innovation and value creation through low-cost dyeing and re-dyeing techniques. Pakistan, a major global textile exporter (Memon et al., 2020), also imports second-hand apparel worth $180 million (2023) and, via creative re-dyeing processes, upcycles these materials for re-export, generating $266 million in value (Maličká, 2024). This form of value creation is termed *jugaad*-based, recursive, and resource-recovery-based, and these practices contribute significantly to the local economy and export markets. Such *jugaad* based frugal innovation-oriented practices is likely to prevail in many Global South countries, specifically Pakistan, Bangladesh and other neighboring states. In many such contexts, waste management still operates under the colonial-era-by-laws that largely address basic urban sanitation and disposal rather than systematic environmental programs. This creates space for informal actors who work in self-organized ways and use *jugaad* practices to create value from waste through recursive resource recovery processes.

Plastic collection typically employs a "bag-in-bag" method, yet the lack of RIC knowledge increases downstream sorting effort and promotes downcycling over upcycling. Most recovered materials are polymers, yet the specific RIC classifications remain unknown, complicating separation processes for recyclers and contributing to a predominance of lower value, downcycled products.

In rural areas, where electronic recycling plants are absent, manual sifting and sorting are the primary methods for processing waste. This approach not only limits recycling efficiency but also poses serious occupational health risks. Workers are frequently exposed to "Polybrominated Diphenyl Ethers" (PBDEs), also called brominated flame retardants, during valorization processes, increasing their vulnerability to multiple adverse health outcomes.

Further, the prevalence of "cut-and-shut" vehicles in the region exacerbates environmental hazards. Improper handling of refrigerants during dismantling can lead to their release into the atmosphere, contributing to ozone layer depletion. These findings align with Ciconkov (2018), who estimates that the release of 1 kilogram of refrigerant gases is equivalent to approximately 2 tons of carbon dioxide. The lack of formal infrastructure for electronic waste processing perpetuates these environmental and occupational vulnerabilities.

4.2. Social Identity, Migration, and Informality

Recycling intermediaries such as waste pickers and aggregators engage in frugal entrepreneurial processes that extract value from discarded materials, particularly in rural areas (Jack & Anderson, 2002). Through low-tech yet innovative RRCs, these actors demonstrate adaptive strategies for transforming waste into economic opportunity. Because waste work is socially stigmatized, many intermediaries seek anonymity by migrating from their home districts, often originating from marginalized tribal communities. This aligns with Yousafzai et al. (2020) who observed that such migrants often develop dual identities shaped by their trans local and borderland experiences.

This study highlights how pro-environmental agency emerges through *jugaad*-type innovations that informally valorize waste and complement government recycling efforts. Informal recyclers often cooperate through collective identities rooted in shared marginalization from formal institutions. Much depends on the means and ends combinations of such recyclers, where some use legal and legitimate means and ends (formal economy). Others use illegal yet legitimate means and ends which constitute informal economy unlike renegade economy where both illegal and illegitimate means and ends of recycling are used(Webb et al., 2009). In the District Malakand, intermediaries consolidate partial truckloads into full shipments through mutual cooperation, effectively substituting for absent government support. Although these actors create socio-environmental value, their activities often remain undocumented, unregulated, and susceptible to unsafe labor conditions and illicit trade. Yousafzai et al. (2020) previously examined sustainopreneurs, engaged in urban waste collection in the urban areas of Peshawar, while Nawaz et al. (2021) documented the self-organized working of recyclers in a larger city of District Swat. By contrast, the present study contributes new insights from rural Malakand, highlighting different social and infrastructural constraints.

4.3. Transboundary Waste Flows and Policy Gaps

There is scant literature on low-tech, informal recycling practices in less developed countries, largely because of the socially stigmatized and hazardous nature of such work. Nevertheless, informal recycling contributes substantially to the economy, environment, and society by way of employment creation and improving livability standards (Gutberlet, 2012). These manual techniques, such as sifting, sorting, and segregation, constitute upstream pre-cycling processes that recycling intermediaries use to supply raw materials to downstream recyclers in urban centers. While some materials, such as textiles, are theoretically recyclable over multiple cycles, expecting complete circularity from the informal sector without government support is unrealistic (Hawley, 2014). Informal systems generally lack the infrastructure to sustain closed-loop processes.

This interpretation aligns with the patterns observed in the OECD (2024) report. Pakistan is the world's second-largest import market for used apparel (approx. USD 180 million) and the sixth-largest exporter of used apparel (USD 266 million), driven in large part by small-scale upcycling and dyeing practices. Similarly, despite having one of the region's largest domestic plastics markets, Pakistan recycles only about 3% of its plastic waste (UNDP, 2022).

Valuable recoverable materials in electronic waste, including copper, gold, nickel, and titanium, are routinely extracted (Mohamad et al. (2007). This is consistent with Sthiannopkao and Wong (2013), who highlight the diversion of e-waste from the Global North to under-regulated economies in the Global South.

There is a relentless flow of waste from the Global North to the Global South, rendering many developing nations de facto dumping grounds for industrialized economies. These largely self-organized transboundary material movements perpetuate a zero-sum dynamic in which a portion of exported waste ultimately re-enters global ecosystems, particularly through oceanic contamination, (Gutberlet, 2023), highlighting the accumulation of waste in the Great Garbage Patch. Pakistan is importing waste from abroad to collect recyclables from scrap, reflecting the absence of a coherent national solid waste management policy and a broader lack of international coordination in waste governance.

4.4. Organic and Animal Waste: Nutrition, Livelihood, and Innovation

Animal-based products account for approximately 18 % of global caloric intake, yet an estimated 80 billion animals are slaughtered annually. Each day, over 900,000 cows, 1.4 million goats, and 1.7 million sheep are processed worldwide, excluding aquatic species (Roser, 2023; Zakaria, 2020). In addition, during Eid Al Azha, 6.6 million cows and other animals, valued at about USD 1.3 billion, are sacrificed in a single day (Mouftah, 2022). While debates around "meat shaming" and *Cowspiracy* persist, these ritual practices provide essential nutritional support to low-income households and generate secondary economic activities. They also support the production of value-added goods such as petroleum-jelly products, glue, gums, crockery, and edible oils.

In the underserved rural areas of Malakand District, more than 40 % of livelihoods depend on animal husbandry (Hameed et al., 2022). The sale and recycling of animal byproducts sustain local economies, demonstrating how traditional practices intersect with informal innovation to enhance both nutrition and income security.

5. Conclusion

This study assessed the frugal recycling practices of intermediaries in rural Malakand through the lens of recursive resource recovery cycles (3RCs). Using an inductive qualitative design grounded in local ethnographic knowledge, the study identified a variety of primary, secondary, and tertiary reuse and recycling strategies. These activities, which are often rooted in undocumented cash-based transactions, reflect both economic precarity and creative adaptation. Significant waste valorization occurs via upcycling and downcycling, supplemented by the collection of flood-borne materials such as sand, stones, and timber.

Over time, monetization from recyclables has increased in rural areas, illustrating the latent potential of informal recycling networks. However, awareness of universal recycling codes and of the health impacts of PBDE exposure remains limited. Industrial upcycling is concentrated in urban centers, whereas rural areas rely primarily on downcycling, indicating uneven integration into the national circular economy. Strengthening logistics, transport safety, and material traceability is critical, as the informal repair and repurposing of vehicles—known as "cut-and-shut" practices—pose risks to workers and consumers alike.

The study highlights that self-organized informal supply chains, including waste pickers, aggregators, dealers, and transporters, often outperform formal waste management systems in operational efficiency, but require institutional support through structured buy-back programs and health monitoring schemes. If *jugaad*-based practices remain unregulated, their environmental repercussions, including the release of refrigerants, the accumulation of heavy metals and plastics, and transboundary PBDE contamination, could exacerbate global public health and marine pollution challenges. Without institutional recognition, these networks may also facilitate illicit trade and unsafe working conditions. Policy frameworks should integrate formal and informal recycling systems to address infrastructure, quality, safety and circularity gaps.

This research contributes a new understanding of low-cost frugal business-model innovations for recycling-based valorization and revalorization in rural Pakistan. This grounded theory-based study offers a logic diagram or framework which acts as stepping stone for further theoretical development and to inform public policies for timely interventions. Future studies should investigate event-based waste streams, such as those generated during Eid Al Azha, elections, and Independence Day festivals, and explore the under-documented practices of vehicular recycling associated with non-custom-paid vehicles transiting to Afghanistan. Overall, this study demonstrates how marginalized human agency and *jugaad*-type innovation foster livelihood security, pro-environmental behaviors, and embed circular economy principles within informal rural economies of the Global South.

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Declarations

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