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Exploring the Role of Scrap Markets in Advancing the Circular Economy in Nepal: A Field-Based Study

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Abstract
Scrap markets have become an integral component of sustainable waste management and circular economy (CE). Through the descriptive field-based research in four urban municipalities of Kailali District, Nepal, this study explores the role of scrap markets in advancing circular economy (CE). Surveys with 54 scrap firm owners shows that the informal sector contributes over 92% of traded scrap, where cycle hawkers alone accounting for 86.47%. Small, unregistered firms buy scrap from informal collectors and sell to larger dealers for recycling and export scrap to industries. The market monthly trades an average of 2,223.54 tons with a net profitability of 6.13%. Glass bottles (53.51%), metal scrap (18.99%), and paper scrap (18.80%) dominate the market, with paper scrap among the most profitable items except Burnt engine oil. Scrap markets support environmental sustainability by reducing landfill pressure for municipal waste. Raising recycling awareness on communities, formalizing informal scrap collectors and infrastructural development for micro-segregation of municipal waste can enhances overall circular economy outcomes.
Keywords: Scrap market, Circular economy (CE), Environmental sustain ability, Recycling, Informal sector

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1. Introduction

Globally, scrap markets have become an integral component of sustainable waste management, resource efficiency, and circular economy (CE) practices. By facilitating the recycling and reuse of discarded materials, they significantly reduce landfill burdens, conserve natural resources, and minimize greenhouse gas emissions (Wilson et al., 2006a). The sector also generates substantial employment opportunities, particularly in developing regions, where informal and semi-formal scrap trade supports the livelihoods of marginalized groups, including waste pickers and small-scale traders (Farzadkia et al., 2021). Despite these contributions, scrap markets often operate informally, lacking proper regulation, standardized pricing, and institutional support (Bake et al., 2024).

In many developing countries, rapid urbanization and industrialization have intensified waste generation, creating both challenges and opportunities for scrap management. Informal scrap trade fills gaps left by inadequate municipal systems, while also providing raw materials for industries and employment for vulnerable communities. However, weak waste segregation practices, insufficient investment in recycling technologies, and fragmented policy frameworks hinder efficiency and scalability (Environment, 2024). Additional barriers such as restrictive taxation policies, licensing challenges, and the absence of comprehensive CE strategies further constrain sectoral development (Lawal, 2024). A large share of recyclable waste—particularly plastics, metals, and paper—still ends up in landfills, highlighting the need for stronger integration of scrap markets within CE models. Circular economy (CE) approaches, which prioritize resource recovery, through recycling, reusing and recovering, which promote sustainable utilization of materials, offer a viable solution to these challenges.

Scrap markets serve as critical intermediaries in the CE transition by enabling the collection, valuation, and trade of reusable materials. They not only reduce environmental burdens but also generate revenue for local governments and create inclusive economic opportunities. Generally, scrap dealers (*kabadiwalas*) purchase metals, paper, and plastics and channel them into local, national, and international recycling markets. This process reflects the broader concept of scrap management, which involves the systematic collection, segregation, processing, and resale of discarded materials that still possess residual economic or material value (MacArthur, 2013). Effective scrap management supports pollution reduction, resource conservation, and the advancement of CE principles (Korhonen et al., 2018).

Depending on the consumer and economic conditions of any nation, the volume of scrap items may be changed but the general categories are similar. However, agricultural byproducts or organic materials may not be considered as scrap items in poor and least developing nations. Efficient scrap management reduces pressure on landfills, mitigates environmental degradation, and conserves natural resources. It also supports employment generation and resource efficiency, particularly in developing economies where informal sectors play a dominant role in waste handling and recovery. The circular economy (CE) framework provides a foundational theory for understanding the significance of scrap item management in a modern, resource-conscious economy. CE promotes restorative and regenerative design to keep products, components, and materials circulating in the economy for as long as possible (MacArthur, 2013). Unlike the linear economy model that follows a take–make–dispose model, the circular model views waste differently like scrap items which is not as an end product but as a resource (Geissdoerfer et al., 2017). Scholars argue that effective scrap recovery, reuse, and recycling are vital in closing material loops, thereby reducing the ecological footprint of human activities and enhancing economic resilience and environmental sustainability (Korhonen et al., 2018).

From an environmental economics perspective, scrap management addresses negative externalities associated with unmanaged waste, such as pollution, biodiversity loss, and public health risks. By internalizing these costs through recovery and recycling, scrap markets align with Pigovian principles that promote corrective measures for market failures (Pigou, 1920; Foundation, 2016). At the same time, the waste management hierarchy prioritizes reduction, reuse, and recycling above recovery and disposal (EU Commission, 2020), positioning scrap management as central to CE strategies. Institutional theory further emphasizes the importance of governance, regulations, and partnerships—including public–private collaboration and community participation—in shaping waste management outcomes (Debrah et al., 2021; Genc, 2024). Without collective action, unmanaged scrap risks becoming a "tragedy of the commons," undermining environmental quality (Ostrom, 1990).

CE can be interpreted as an economic system in which the end-of-life of products and materials is reduced through circular strategies such as reusing and recycling. This principle is being transversally adopted by most sectors and countries to transform waste management and create close loops of materials and energy which resource depletion and to restore material loops through recycling, reuse, and recovery (Geissdoerfer et al., 2017). Empirical studies highlight the role of informal recycling systems across South Asian cities such as Delhi, Lahore, Rajshahi, and Kathmandu, where scrap pickers and traders recover substantial quantities of reusable materials, reducing landfill pressure and supplying remanufacturing industries (Visvanathan & Norbu, 2006; Suthar et al., 2016). Scrap markets remain underdeveloped, operating under informal structures with limited recognition, infrastructure, and policy support from the government of Nepal (Pathak, 2019).

In many developing countries, the trading of scrap materials with direct market value extracted from municipal solid waste (MSW) has been a long-standing practice. However, effective MSW reduction in urban areas remains a challenge due to limited technological progress and financial constraints. According to Pant, (2024) in Bheemdatt municipality Kanchanpur Nepal indicates that the technological constraints, poor financial investment and emerging quantity electronic scrap items are major challenge to manage municipal level solid waste however the significant contribution of recyclable items in circular economy. Under such circumstances, waste recycling has emerged as a practical and sustainable strategy to reduce the volume of waste being sent to landfills and to conserve valuable resources (Bhaskar & Turaga, 2018; Environment, 2024). Importantly, in these regions, recycling activities often serve as a critical source of livelihood for economically disadvantaged communities (Wilson

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et al., 2006b). In contrast, waste recycling and recovery practices in industrialized nations are generally driven by environmental policies, active citizen engagement, and government regulations.

The scrap market offers significant economic benefits by providing recyclable items for reducing production costs, stimulating industry innovation, and lowering municipal waste management expenditures. For example, recycling aluminum can save up to 95% of the energy required for primary production, while recycled plastics save up to 70% compared to virgin alternatives (Turner & Kim, 2024; Genc, 2024). Such savings strengthen industry competitiveness while reducing environmental footprints. However, economic viability depends on factors such as collection, transportation, and processing costs, alongside fluctuating market prices for recyclables (Wilson et al., 2006b; Tseng et al., 2020).

Scrap market management plays a vital role in environmental sustainability; however, it is dominated by informal actors such as kabadiwalas, whose role in waste recovery and livelihoods is vital but often unrecognized. Studies suggest that optimizing recyclable waste management could reduce landfill burdens by up to 30%, create local employment opportunities, and generate net economic benefits. However, research on the scrap sector remains limited, leaving gaps in understanding its contributions to CE and sustainability. The guiding principles of the UN-SDGs, such as public health, environmental concerns, resource value, and economic development are like those that have driven the growth of waste management activities; thus, to achieve the goals of UN-SDG, a circular economy approach in solid waste management system should be prioritized, where the volume of municipal solid waste (MSW) is increasing due to rising population, changing consumption patterns and income levels fluctuation (Velis, 2014). Sustainable solutions of solid waste which increase scrap quantity such as the “3R” approach which include reduce, reuse, and recycle principles are widely promoted for both environmental conservation and resource efficiency (Korhonen et al., 2018). Recycling is not only conserves natural resources and energy but also significantly reduces the waste collection and disposal costs by providing scrap items as raw materials for new material production in industries (Labra Cataldo et al., 2024; US EPA, 2016).

Market conditions and infrastructure critically influence recycling’s economic viability. Fluctuating prices for plastics, paper, and metals, along with contamination levels, affect processing costs and program sustainability, sometimes requiring financial support (Wilson et al., 2006; Tseng et al., 2020). Substantial investments in recycling plants, sorting equipment, and logistics are necessary, with ongoing maintenance and upgrades; in the U.S., this may reach $36.5–$43.4 billion (U.S. EPA, 2021). Despite costs, recycling reduces waste management expenses, cutting landfill, transport, and disposal costs by up to 50% for businesses (Buchen, 2024). Case studies in Taiwan and Australia highlight additional economic gains, including resource recovery, cost savings, and job creation (Tsai, 2021; Toumbourou, 2024). By facilitating the collection and trade of scrap materials, recycling systems and scrap markets directly contribute to advancing the circular economy.

Considering concepts and definitions of different literatures, this research defined circular economy as, “the circular economy is defined as an economic system that minimizes

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waste and maximizes resource efficiency by keeping materials in continuous circulation through reduction, reuse, repair, and recycling by engages both formal and informal actors. It promotes environmental sustainability and economic opportunities by reducing pressure on natural resources and supporting sustainable resource management."

In this context this study addresses the existing research gap by exploring the role of scrap markets in advancing the circular economy. It investigates how scrap markets contribute to resource recovery, economic opportunities, and environmental sustainability, with particular emphasis on their sources, trade mechanisms, and overall cost–benefit outcomes. Guided by the research question—In what ways do scrap markets contribute to advancing the circular economy? the primary objective of this study is to explore and analyze the role of scrap markets in advancing the circular economy, with a particular focus on their contributions in terms of scrap sources, trade mechanisms, and overall cost–benefit outcomes.

2. Materials and methods

(i) Research design

The research design for this study adopts a mixed-method. The study follows a structured plan of action that begins with a review of secondary sources such as policy documents, municipal records, and existing literature related to waste management and scrap trading. This helped establish a contextual foundation and identify data gaps. For primary data collection, field observations were conducted to understand operational practices and estimate the population involved in scrap trading. Through this, it was determined that there were 55 scrap dealers directly engaged in scrap items collection and trading. Semi-structured field survey was conducted to owners of scrap dealers to collected the primary data of the study. To gather accurate trading volume of scrap items, Key Informant interviews (KIIs) were conducted with scrap contractors of different municipalities, municipal authorities. Field surveys were conducted between November, 2024 and September, 2025. In addition, a complete tax payment slip was reviewed for fiscal year 2081/082 B.S. from scrap contractor's office to verify the data collected from firms and government record.

(ii) Study Area Description

Kailali District, located in the fertile Terai plains of Sudurpashchim Province (Province No. 7), is one of Nepal's seventy-seven districts, covering an area of 3,235 square kilometres with a population of 904,666 (CBS, 2022 census). Dhangadhi, the district headquarters, is also the capital of Sudurpashchim Province, serving as a major administrative, economic, and educational hub. The district borders Kanchanpur to the west, Bardiya to the east, Dadeldhura and Doti to the north, and India to the south. Its strategic location, fertile land, and growing urban centers make it an important area for studying socio-economic and environmental dynamics.

Administratively, Kailali consists of thirteen local levels, including one sub-metropolitan city, six municipalities, and six rural municipalities. For this study, Dhangadhi Sub-Metropolitan City, Ghodaghodi Municipality, Godawari Municipality, and Gauriganga Municipality were

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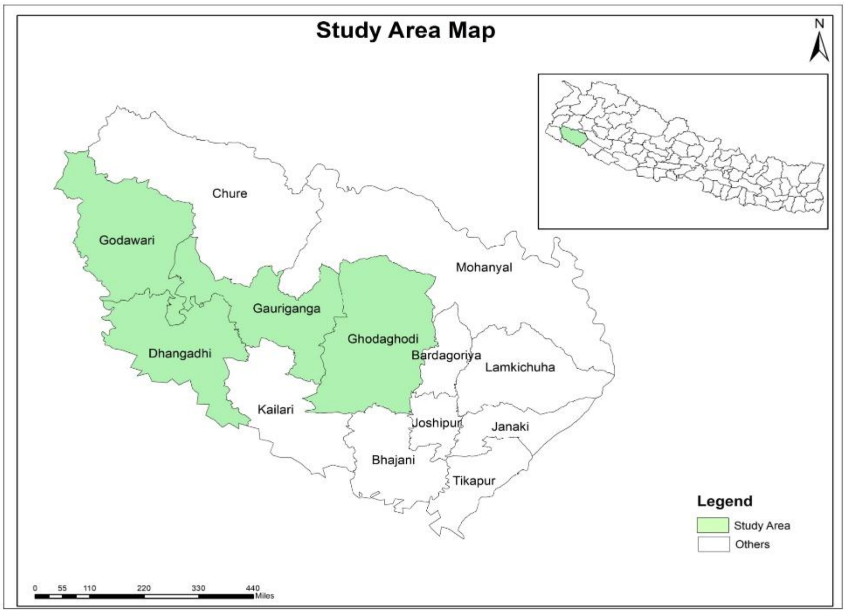
purposively selected. These areas were chosen due to their rapid urbanization, population growth, and increasing pressure on municipal services, particularly solid waste management. The selected municipalities represent diverse socio-economic contexts and provide an ideal setting to examine the role of circular economy practices and sustainable waste management strategies in managing urban growth and resource use effectively.

Kailali district Nepal is purposed capital city of Sudurpaschim province, is experiencing significant demographic and economic growth. Traditionally agrarian, the region is witnessing increasing commercial and industrial activities that directly influence waste generation and recycling demands. The scrap market in kailali has thus emerged as a critical yet informal component of the local economy, offering employment opportunities and contributing to environmental sustainability. However, this market is constrained by fragmented regulations, inconsistent policy enforcement, and limited institutional oversight. Scrap markets contribute significantly to employment generation, raw material supply, and resource efficiency. However, inconsistent policies, insufficient government intervention, and local taxation or licensing requirements often affect the operational efficiency and profitability of scrap traders in many cases (Genc, 2024). Despite its importance, the sector operates largely in an informal and unregulated framework, resulting in inefficiencies, price volatility, inadequate waste segregation, and limited recycling mechanisms which reduce circular economic. The figure 1 shows the study area map.

Figure 1 Map of Study Area



Source: GIS map by researcher

Scrap markets serve as key intermediaries in the circular economy by enabling the collection, trade, and recycling of reusable materials from the municipal waste. These markets not only provide economic opportunities for local communities but also enhance material efficiency and reduce environmental burdens. Similarly, these provides a strong source of revenue for local

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government. Despite their importance, there is limited empirical research in Nepal on how scrap market function, their economic and environmental contributions, and their role in facilitating a circular economy transition. Valuable and easily sellable items such as metals, paper, and clean plastics are purchased by scrap dealers (Kawadis) and trade in national and international recycling markets.

(iii) **Universal and sampling technique**

Population of the study is scrap firms working in the study area. There were 55 scrap firms identified preliminary field visit and these all are considered population of the study. For sample size determination statistical formula propounded by Arkin and Colton, 1963 was used the formula is given as,

$$n = \frac{z^2 * N * p(1-p)}{Nd^2 + z^2 * p(1-p)}$$

where, z = 95% confidence level (1.96)

N = total population of scrap dealers/firms are 55

p = estimated population proportion (0.5)

d = margin of error (0.05)

n = sample size

A total of 54 scrap dealers were selected for data collection and semi-structured interviews were carried out with owners of these dealers. The sample of scrap firms were determined with a 95% confidence level to ensure statistical reliability. This approach helped gather detailed information on their detailed records regarding the scrap market and scrap management practices. The semi-structured format ensured that essential themes were covered while allowing respondents to provide rich, quantitative and qualitative insights that may not emerge in fully structured surveys. Except semi-structured interview, fourteen key informant interviews (KIIs) were taken with scrap contractors (4), municipal section officers (4), recycling company owners (2) and waste management contractors of municipality (4). Secondary data were collected from both official and published sources of municipalities to supplement the primary data and provide contextual and theoretical support for the study. In this case the sample frame is small and Arkin and Colton, 1963 sampling formula was not directly appropriate but in the initial phase of study this sampling formula was planned assuming that the sample size could have larger but in the initial assessment only 55 firms were identified and from the 54 were considered for data collection which was almost census survey. And sampling formula also suggest same size too. Review of published literature from credible online sources was conducted to support the methodological and theoretical foundation of the research.

Data Analysis Techniques

(a) Descriptive analysis

Descriptive analysis is a fundamental statistical method used to summarize, organize, and interpret raw data into meaningful patterns. In the context of scrap market data analysis, descriptive statistics help in understanding market trends, pricing behavior, collection rates,

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and scrap composition and market development in the recycling and circular economy sector. Common tools used in descriptive analysis are mean to determine the central tendency of numerical data which includes average price of different types of scrap (e.g., plastic, metal, paper) over a period. Average quantity of scrap materials collected or sold per months and per year. Similarly, percentage is useful to express proportions or changes in values, especially in comparison of market share of different types of scrap.

(b) Cost benefit analysis

The economic analysis of scrap market was analyzed through cost benefit analysis scrap. The key financial metrics for evaluating recycling operations, including total revenue, total cost, gross profit, profit margin, and cost-benefit ratio were determined which were shown in table 1. This help assess income, expenses, and overall profitability.

Table 1 Tools for economic analysis

Term	Formula	Meaning
Total Revenue (TR)	Quantity (Q) × Selling Price (SP)	Total income from selling the recycled items
Total Cost (TC)	(TVC+TFC) which is, Quantity (Q) × Cost Price (CP) + fixed cost depreciation amount	Total expenditure for purchasing and processing the item
Gross Profit (GP)	TR – TC	Earnings before other costs like marketing or depreciation
Profit Margin (%)	(GP ÷ TC) × 100	Indicator of profitability
Net Profit (NP)	(TR – TC)	Earnings after subtracting all expenditures
Net profit margin (%)	(NP/TC) *100%	TC=TVC+TFC which means sum of all fixed costs (rent + insuran ce + salaries + depreciation, etc.)
Cost-Benefit Ratio (CBR)	TR ÷ TC	Shows how much benefit is gained per unit cost (CBR > 1 = profitable)

Cost-Benefit Ratio (CBR) is a fundamental economic metric used to assess the efficiency and viability of a business operation. The Cost-Benefit Ratio indicates how much revenue is earned for every unit of cost incurred. A CBR greater than 1 implies that the benefits (revenues) outweigh the costs, meaning the activity is economically profitable or efficient. Conversely, a CBR less than 1 suggests that the costs exceed the benefits, and the activity may not be financially viable. This ratio is widely used in both business and development economics to support decision-making and justify investment choices. To analyze the economic status of scrap market this analysis tool was applied.

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3. Results and discussion

(i) Types of Scrap items collected and sold

There are different types of scrap items which vary according to their characteristics and material composition. The classification of scrap items mainly based on the characteristics of original materials and their reusability. This classification helps improve resource recovery and supports the principles of a circular economy. Based on the materials listed, the items have been divided into three categories.

(a) Reusable materials:

Reusable materials or products that can be used again in their original form or with minimal cleaning or repair, without going through an industrial transformation process are reusable materials. Refers to the portion of waste materials that can be used again in their original form without major processing. For example: Glass bottles refilled for reuse, Metal or plastic containers reused for storage. Key Characteristics of reusable items are as follows: Reduces the need for new products, Extends the life cycle of a product and often involves repair, washing, or repurposing.

Reusable items are those that can be used again for the same or a similar purpose without requiring significant processing. In Nepal, several materials fall under this category. White sacks (katta) made from plastic are durable and commonly reused for packaging and storage purposes. Single beer bottles and beverage bottles—such as 8848, Ruslan, Khukuri, and rum bottles—are typically returned, cleaned, and refilled for further use. Wooden furniture items, when damaged or worn out, are often repaired or refurbished to extend their lifespan, reducing the need to produce new wood products.

(b) **Recyclable materials**:

Materials that can be collected, processed, and transformed into new products through industrial recycling systems. This indicates the percentage of materials that can be processed and converted into new products. Recycling typically involves industrial procedures and which includes: Melting down metals for new products, shredding plastic to make pellets, and re-pulping paper to produce recycled paper goods. Key Characteristics of recyclable items is mechanical or chemical processing which convert raw materials to new output.

Moreover, recyclable items, on the other hand, cannot be reused directly but can be processed into new products, which helps reduce the extraction and use of raw materials. Paper products like newspapers, cardboard, and used books are widely recyclable into new paper items. Metals such as iron, zinc, aluminum, steel, copper, and brass hold high recycling value and are commonly collected and processed. Glass materials, even if cracked or broken, can be melted and reshaped into new glass products. Various types of plastics, including multi-layer plastic scrap, and rubber items like tires and tubes, can be recycled using appropriate methods. Electronic and electrical waste such as old radios, TVs, mobile phones, computers, wires, and batteries contain valuable metals and components suitable for recycling. Agricultural byproducts including rice husk, bran, and pina, as well as animal body parts like skin and bones, are also recyclable and can be converted into agricultural or industrial inputs. Additionally,

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chemical and liquid waste such as used motor oil and lubricants are recyclable when processed at specialized facilities.

(c) Reusable and recyclable items:

Recyclable or Reusable materials also called "Reusable and Recyclable" materials that can either be reused directly or recycled, depending on their condition and the available resource management options. This represents the overlap the materials that can either be reused directly or recycled, depending on the waste management system in place and the condition of the materials. The key characteristics of these items are, offers flexibility in scrap waste management, maximizes material recovery. The end-use decision (reuse or recycle) depends on contamination, durability, or convenience.

Reusable and recyclable items offer the dual benefit of being used multiple times before eventually being processed into new products. For instance, plastic bottles like PET bottles are often reused for storing liquids and can later be recycled into polyester fibers or new containers. Plastic materials such as polythene pipes (PP), LD/HM, PVC, and ropes are sturdy enough to be reused and can also be recycled once their usability ends. Aluminum and steel containers are durable and can be reused in their original form or recycled when damaged or no longer functional. Glass bottles, as long as they are not broken, are frequently reused and, if damaged, are recycled. Similarly, brass and copper items used in households and industries serve multiple purposes before being collected for recycling. Lastly, plastic toys like "Gudiya" and some decorative plastic items can be used repeatedly and are recyclable depending on their composition.

(ii) Source of Scrap items

The scrap material supply chain in the study area is dominated by informal actors, highlighting the crucial role of community-based waste collectors in resource recovery. As shown in Table 2, cycle hawkers (informal collectors using bicycles) contribute the highest proportion of scrap materials, accounting for 86.47% of the total inflow.

Table 2. Source of scrap materials

Source of Scrap materials	Percentage (%) of contribution
Municipal waste sorting	0.44
Cycle hawker (informal collectors using cycles)	86.47
Waste picker (manual collectors from streets or dumping sites)	7.32
Government tender or contracts	1
Individuals who bring and sell scrap at the shop	1.56
Others (from different location outside district)	3.21
Total	100

Waste pickers—manual collectors who recover materials directly from streets, dumping sites, and other public spaces—make up 7.32% of the supply. Together, these two groups provide over 93% of scrap inputs, underscoring the significance of the informal sector in maintaining material circulation and reducing the waste burden on municipal systems.

Other sources contribute relatively smaller shares. Scrap derived from municipal waste sorting represents only 0.44%, indicating limited formal recovery by local governments. Similarly, government tenders or contracts contribute about 1%, while individuals who bring and sell scrap directly to shops account for 1.56%. Generally, old vehicles, metal scrap and cardboard have bringing by individuals in scrap shops. Scrap sourced from outside the district or other locations contributes 3.21%.

These findings align with previous research, which emphasizes that informal collectors—particularly cycle hawkers and waste pickers—form the backbone of recycling systems in South Asia, often supplying more than 80% of recyclable inputs to scrap markets (Wilson et al., 2006b; Wilson et al., 2009; Scheinberg et al., 2010). This pattern confirms the findings of Pathak & Mainali,(2019) who emphasized the importance of integrating informal collectors into municipal waste strategies for improved efficiency and inclusiveness Their activities not only provide livelihoods for marginalized groups but also support the circular economy by diverting significant volumes of recyclable materials away from landfills.

(iii) Trading system of Scrap

The complete scrap market management and trading system is shown in the diagram 1. The diagram illustrates the flow of scrap materials from generators to end users and markets. Scrap is generated by households, markets, and industries and collected by both formal and informal collectors, including cycle hawkers, waste pickers, municipal waste collectors, and individuals selling directly through firms or government tenders. It shows that different stakeholders were engaged from collection of scrap from source to the final trade.

Collected scrap flows to small firms without processing machines who generally works for large registered firms. Large firms generally purchase scrap items from small firms and other stakeholders and sold it after minimal cleaning and baling through proper technology. Before selling large firms with or without processing machines both paying local government taxes through a collection contractor. The tax rate of local government for different scrap items is different in municipalities. Collected scrap finally either transported to recycling industries in Nepal or exported to India and other foreign markets. Few scrap items are sold to local recycling users from scrap firms too. Finally, recycling industries use this scrap as raw materials or export to international market after processing. The complete process of scrap market is shown in complete scrap process diagram listed in figure 2.

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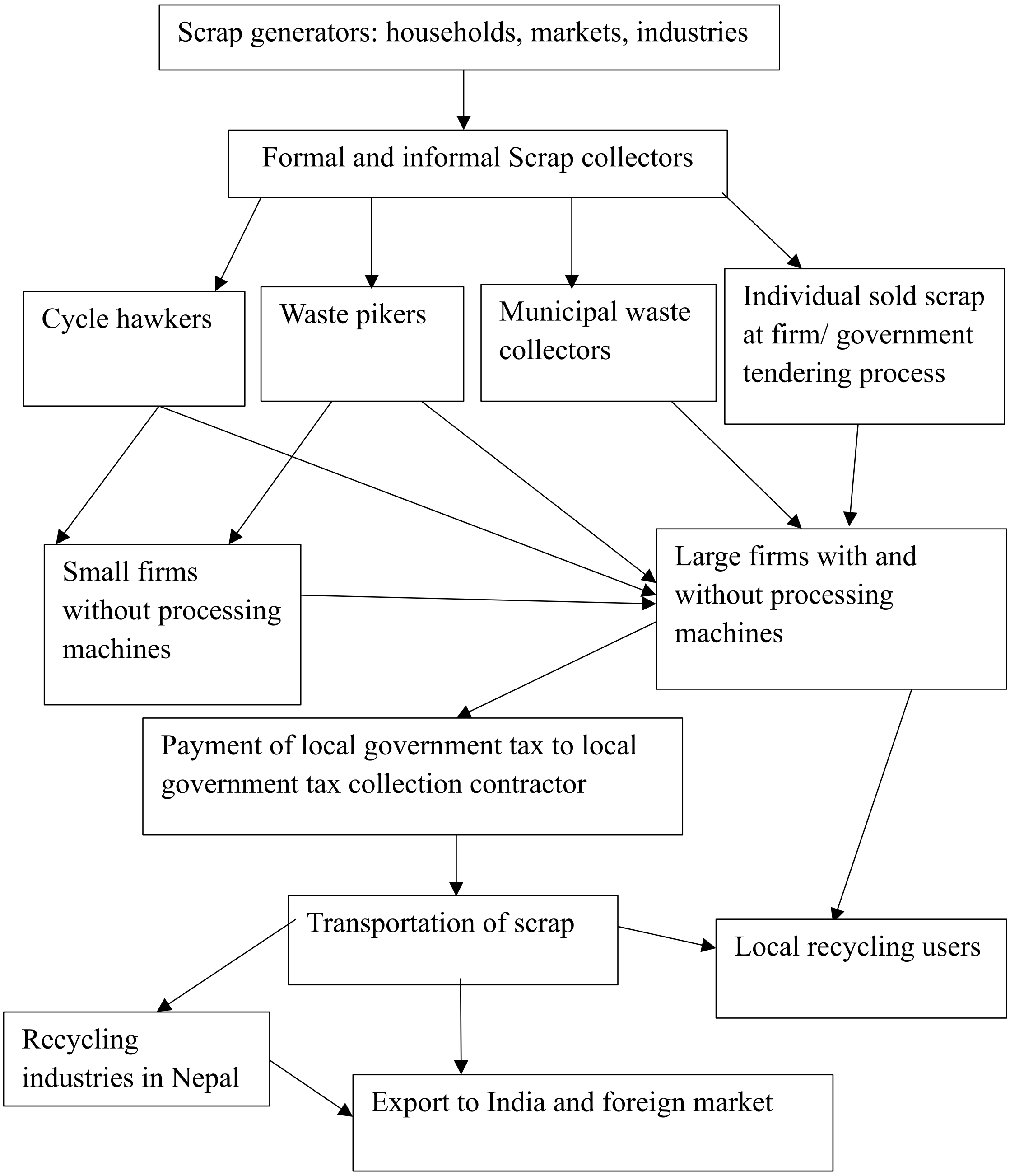
Figure 2 Material follow diagram of scrap market



The diagram highlights the central role of informal collectors in supplying both small and large firms, the link to tax collection, and the eventual movement of materials into domestic recycling and international markets.

Trading quantity

From the three years data the monthly trade volume and name of scrap items are clearly mentioned in table 3. Table 3 shows that the analysis of the composition of scrap materials reveals the distribution of different recyclable and waste components in the collected waste

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stream. According to the data, glass scrap constitutes the largest portion, accounting for 53.514% of the total scrap collected, with beer bottles alone contributing 42.925% and other cracked glass contributing 10.589%.

Table 3 Detailed breakdown of items and quantity of scrap sold per month

SN	Name of items	Unit	Total	Composition %	Remarks
1	Paper products-Cardboard	Tons	321.17	14.386%	Total paper scrap is 18.801%
2	Used paper/books/A4, etc (raddi)	Tons	67.86	3.040%	
3	Paper pieces scrap (jhura paper)	Tons	30.71	1.376%	
4	Plastic items-PET bottle	Tons	83.82	3.754%	Total plastic scrap is 6.126%
5	Other plastic items	Tons	52.94	2.371%	
6	Metal items-Iron and tina	Tons	399.92	17.913%	Total metal scrap is 18.994%
7	Aluminum and silver	Tons	22.05	0.988%	
8	Steel	Tons	1.42	0.064%	
9	Cupper	Tons	0.62	0.028%	
10	Other metal-yellow metal	Tons	0.036	0.002%	
11	Glass scrap-Beer bottles	Tons	958.31	42.925%	Total glass Scrap is 53.514%
12	Other all cracked glasses	Tons	236.41	10.589%	
13	Rubber scrap-Tires and tubes	Tons	38.9	1.742%	Total rubber is 1.742%
14	Electrical scrap-old batteries	Tons	17.3	0.775%	Total electric scrap is 0.775%
15	Burnt engine oil	Tons	1.07	0.048%	Liquid form of burnt engine oil is 0.048%
	Total	Tons	2232.54	100.000%	

Source: Field Survey, 2025

This indicates that glass is the dominant waste material, reflecting high consumption of bottled beverages and the need for efficient glass recycling strategies (Hoornweg & Bhada-Tata, 2012). However, in many urban areas, glass bottles are still the preferred packaging material because of their durability, reusability, and consumer preference for quality preservation of beverages (Ling et al., 2013). Metal scrap is the second most significant category, making up 18.994% of the total waste. Within metals, iron and tin constitute the majority (17.913%), followed by aluminum and silver (0.988%), steel (0.064%), copper (0.028%), and other yellow metals (0.002%). This composition suggests potential economic value for metal recovery through recycling initiatives (Graedel et al., 2011).

Paper products contribute 18.801% of the total scrap, with cardboard forming the largest share (14.386%), while used paper/books and paper pieces make up 3.040% and 1.376%, respectively. The significant presence of paper highlights the potential for recycling and reuse,

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which could reduce pressure on landfills and promote sustainable resource management (Hoornweg & Bhada-Tata, 2012). Plastic items account for 6.126% of the total scrap, dominated by PET bottles (3.754%) and other plastic items (2.371%). Although plastics are a smaller fraction compared to glass and metal, their non-biodegradable nature necessitates targeted collection and recycling measures to mitigate environmental pollution (Geyer et al., 2017). Rubber, electrical, and liquid waste constitute relatively small portions, at 1.742%, 0.775%, and 0.048%, respectively. Rubber scrap primarily includes tires and tubes, whereas electrical scrap consists of old batteries. The low proportion of liquid Burnt engine oil suggests limited improper disposal of hazardous liquids, but its proper management is essential to prevent soil and water contamination (U.S. Environmental Protection Agency (EPA, 2016)).

This pattern is consistent with broader trends observed in national and international contexts. According to (Sahani et al., 2025) beverage bottles constitute the majority of post-consumer glass collected by scrap dealers in urban Nepal due to their economic value and ease of transport. However, poor operational efficiency and inadequate infrastructure for micro-segregation of reusable items from municipal solid waste increase the landfill of scrap items from solid waste and minimize the potential scrap items in scrap market in Nepal (Pant, 2025). Internationally, (Baek et al., 2024) found that in European waste systems, beverage glass—especially from beer and soft drinks—has a high collection and recycling rate, supporting circular economy strategies. The recycling of glass bottles plays a key role in reducing energy consumption and raw material extraction, as re-melting glass for new bottles consumes significantly less energy than producing new glass from virgin materials.

These findings underline that glass beverage bottles are well integrated into the circular economy due to their recyclability, market demand, and well-established supply chains. Enhancing collection efficiency and infrastructure for non-beverage glass could further strengthen circular material flows in the glass sector. The predominance of beer and beverage bottles over other forms of glass waste suggests that alcoholic beverage containers are more frequently collected, traded, and reintegrated into the scrap economy compared to general-purpose glassware. This trend may be attributed to the standardized shape and higher resale value of glass bottles used in commercial alcoholic beverages, making them more attractive for collection by both formal and informal waste collectors. The consistency in volume and demand of these bottles in the secondary market reinforces their economic viability within the waste recovery system. In the rubber items category, Tires and tubes contribute 38.9 tons per month, highlighting a sizable share of automotive-related waste. Furthermore, burnt engine oil indicating a smaller quantity of liquid waste as reusable material. The major categories of scrap quantity trading market per month based on the three years data is shown figure 3.

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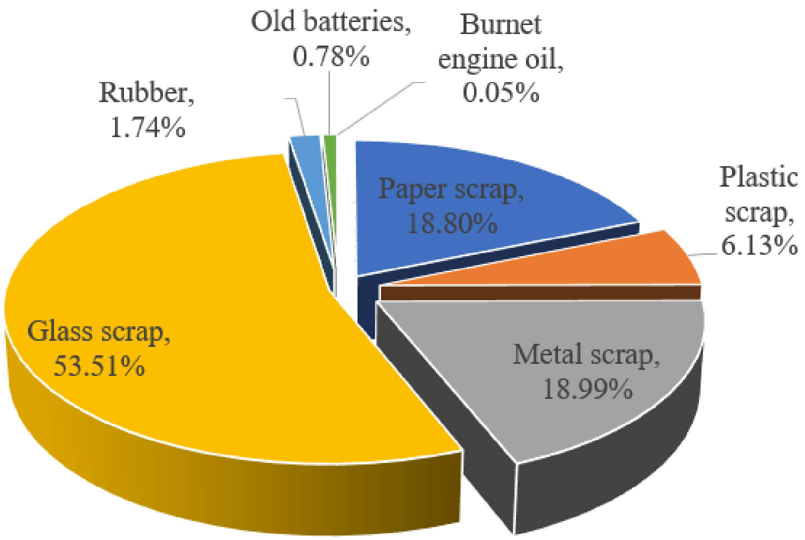
Figure 3 Composition of monthly trade quantity of scrap in market



Source: Researcher's calculation

Figure 3 shows glass are major recyclable items, metal scrap and paper items follow in second and third position. of the monthly recyclable waste stream. According to the "Economic Analysis of Recyclable Waste Management Systems in Bheemdatt Municipality" by Pant, (2024) paper is one of the most profitable and frequently traded waste materials, due to its relatively high volume and established market chain involving collectors, aggregators, and paper industries. The high market value and global demand for metals make meal scrap as staple in both local and export recycling streams. Recyclable metals are often collected separately and sent to smelting industries or exported to neighboring countries like India.

In contrast, plastic waste, while often a major concern globally, accounts for only 6.13% in this dataset. This may reflect that plastic recycling remains a growing sector, especially through community-led initiatives and partnerships with private recyclers. Globally, plastic waste poses significant environmental threats(Shanker et al., 2023). Electrical and oil waste, although lower in quantity, are classified as hazardous and require specialized handling. The presence of such items highlights emerging challenges for handling electronic and chemical waste. The Global E-waste Monitor and local analyses suggest that these waste types, if not managed correctly, can pose significant risks to environmental and human health (Shittu et al., 2021).

Overall, the data reflects that glass, metal, and paper are the primary recyclable components, representing over 90% of the total scrap. These findings can inform municipal solid waste management strategies, emphasizing targeted collection, segregation, and recycling programs to enhance resource recovery, environmental sustainability and circular economy.

(ii) **Economic analysis of Scrap market**

To understand the viability and dynamics of the scrap market, a detailed economic analysis of the scrap market was conducted. This analysis focuses on the cost-benefit structures, income patterns, material value chains, and profitability across different material categories. To provide

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a comprehensive picture of the economic interactions of scrap market, complete cost benefit analysis has been conducted. value chain analysis for individual cases is explained separately. The total monthly trade quantity across the three scrap firms involved handling 2232.54 tons of various recyclable materials. The detailed data is listed in table 4.

Table 4 cost benefit analysis for scrap firms

SN	Name of items	Quantity (Q) in Tons	Purchasing Price (NPR)	Per unit cost (NPR)*1000					Total cost amount (TC) = (Q*CP)	Selling Price (SP)*1000	Total Revenue (TR)= (Q*SP)*1000	Gross Profit (GP)= (TR-TC)*1000	Gross profit margin % = (GP/TC)*100
				Labor	Technology	Other cost (government tax, miscollenaus)	Transportation cost	Per unit cost price (CP)					
1	paper products-Cardboard	321.17	12	1	1	3	2	19	6102.23	22	7065.74	963.51	15.79%
2	Used paper/books/A4, etc (raddi)	67.86	10	1	1	3	1.9	16.9	1146.834	20	1357.2	210.366	18.34%
3	Paper pieces scrap (jhura paper)	30.71	11	1	1	3	1.9	17.9	549.709	20	614.2	64.491	11.73%
4	Plastic items-PET bottle	83.82	32	1	2	5	2	42	3520.44	45	3771.9	251.46	7.14%
5	Other plastic items	52.94	18	2	2	5	2	29	1535.26	32	1694.08	158.82	10.34%
6	Metal items-Iron and tina	399.92	40	1	1	8	1.7	51.7	20675.864	54	21595.68	919.816	4.45%
7	Aluminum and silver	22.05	65	1	1	8	1.7	76.7	1691.235	85	1874.25	183.015	10.82%
8	Steel	1.42	55	1	0.5	8	1.7	66.2	94.004	75	106.5	12.496	13.29%
9	Cupper	0.62	900	2	0	15	1.7	918.7	569.594	1050	651	81.406	14.29%
10	Other metal-yellow metal	0.036	600	2	0	15	1.7	618.7	22.2732	650	23.4	1.1268	5.06%
11	Glass materials-Beer bottles	958.31	4	1	0	2.5	2.5	10	9583.1	11	10541.41	958.31	10.00%
12	Other all glasses/Cracked glasses	236.41	4.4	1.5	0	2.5	2.2	10.6	2505.946	12	2836.92	330.974	13.21%
13	Rubber items-Tires and tubes	38.9	11	2	1.5	3	3	20.5	797.45	23	894.7	97.25	12.20%
14	Electrical Items-Old batteries	17.3	140	1	0	15	2	158	2733.4	177.5	3070.75	337.35	12.34%
15	Burnt engine oil	1.07	20	2	0	3	0	25	26.75	30	32.1	5.35	20.00%
	Total	2232.5							51554.0892		56129.83	4575.7408	8.88%

Source: Field survey, 2025

The economic analysis of the scrap market reveals important insights into the profitability, efficiency, and role of different categories of recyclable materials in the circular economy. A total of 2,232.54 tons of scrap materials were traded during the study period, generating a total revenue of NPR 56,129.83 thousand against a total cost of NPR 51,554.09 thousand. This resulted in a gross profit of NPR 4,575.74 thousand, corresponding to an overall gross profit

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margin of 8.88%. Although the profit margin is modest, it demonstrates the significant economic contribution of the scrap sector to resource recovery and waste diversion.

Among the different categories, paper and glass materials emerged as dominant contributors in terms of both traded quantity and revenue. Cardboard and mixed paper types together accounted for over 419.74 tons of trade with profit margins ranging from 11.73% to 18.34%, highlighting their stable demand in recycling industries. Similarly, glass, particularly beer bottles (958.31 tons), represented the single largest traded item by volume, contributing substantially to revenue (NPR 10,541.41 thousand) with a profit margin of 10%. The high share of glass in the scrap stream may be attributed to its durability, high consumption rate in urban areas, and efficient collection system through reuse and recycling chains (Ling et al., 2013).

Plastic materials such as PET bottles and other plastic items also played a crucial role in revenue generation. PET bottles alone contributed 83.82 tons with a profit of NPR 251.46 thousand, though the profit margin (7.14%) was relatively lower compared to paper and glass. This indicates that despite higher per-unit costs due to transportation and handling, plastics remain vital for the scrap economy owing to consistent market demand for recycled plastic in manufacturing.

The metal category, including iron, aluminum, copper, and steel, showed mixed economic performance. Iron and tin were the second-largest traded category by volume (399.92 tons), but their profit margin was only 4.45%, reflecting higher costs associated with labor, handling, and market price fluctuations. These metal scrap required advance recycling companies and which are costly and transportation cost and handling process requires more more resources which reduce the profit margin for these items. In contrast, non-ferrous metals such as copper and aluminum exhibited higher profit margins (14.29% and 10.82%, respectively), despite lower traded volumes, underscoring their higher unit value and strong demand in industrial applications. Other categories, such as rubber (12.20% margin), electrical waste (12.34% margin), and used engine oil (20% margin), though contributing lower volumes, demonstrated relatively high profit percentages. Used engine oil is generally sold in local market, where construction contractor used it for beam setting processes. Additionally, a significant portion of it goes to the Indian market direct through unauthorized channels, which increase it's demand and consequently rise the profit margin. This suggests niche opportunities for specialized recycling businesses to capitalize on these waste streams with improved collection and processing efficiency.

Overall, the findings indicate that while bulk scrap categories like glass, paper, and iron dominate in volume, niche items such as aluminum, copper, batteries, and engine oil can yield higher profit margins. These dynamics highlight the dual nature of the scrap economy: large-scale materials ensure steady turnover, while specialized items ensure profitability. Moreover, the scrap market plays a critical role in promoting the circular economy, reducing landfill pressure, and supporting livelihoods, especially in developing countries where informal collection networks are significant contributors (Scheinberg et al., 2010).

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(iii) Cost-benefit analysis of scrap market

Study results in table 5 shows the comparative financial overview of scrap market. For economic analysis the information includes key financial indicators such as total revenue, variable and fixed costs, depreciation, and gross profit, calculated on monthly bases. Comprehensive economic analysis which includes Cost-Benefit Analysis (CBA), Cost-Benefit Ratio (CBR), and profit margin for scrap traders especially small and unregistered firms, large firms without machine and large firm with machine based on the calculated data clearly shows the economic analysis of scrap market. The economic analysis of the recycling business demonstrates that it generates a total revenue (TR) of NPR 56,129.83 per month from selling recycled items, while incurring a Total Variable Cost (TVC) of NPR 51,554.09 and a Total Fixed Cost (TFC) of NPR 1,335.01. This results in a Total Cost (TC) of NPR 52,889.10. Consequently, the business achieves a net profit (NP) of NPR 3,240.73, with a Cost-Benefit Ratio (CBR) of 1.06 and a net profit margin of 6.13%, indicating moderate but stable profitability.

Table 5 Comprehensive economic analysis for scrap market

Sn	Economic indicators	Calculated value	Remaks
1	Total Revenue (TR)	56,129.83	Total income from selling the recycled items
2	Total Variable Cost (TVC)	51,554.09	Total expenditure for purchasing and processing the item
3	Total Fixed Cost (TFC)	1,335.01	Sum of all fixed costs (rent + insurance + salaries + depreciation, etc.)
4	Total Cost (TC = TVC + TFC)	52,889.10	Total expenditure for purchasing and processing the item + fixed cost depresecation amount
5	Net Profit (NP = TR – TC)	3,240.73	Earnings after subtracting all expenditures
6	Cost-Benefit Ratio (CBR = TR/TC)	1.06	Shows how much benefit is gained per unit cost (CBR > 1 = profitable)
7	Net profit margin (%)=(NP/TC)*100%	6.13%	Indicator of profitability

By subtracting the total cost from total revenue, the business achieves a net profit (NP) of NPR 3,240.73, indicating that the operation is financially viable. The Cost-Benefit Ratio (CBR) is calculated as 1.06, which is greater than 1, confirming that every unit of cost invested yields a positive return. Similarly, the net profit margin of 6.13% reflects moderate profitability and demonstrates that the business can sustain itself while contributing to economic and environmental goals.

These economic indicators underscore that the recycling business is not only financially viable but also plays a critical role in promoting a circular economy. By collecting, processing, and selling scrap materials, the business ensures that resources which would otherwise contribute to landfill accumulation are reintegrated into productive use. This process reduces environmental pollution, conserves raw materials, and mitigates the depletion of natural

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resources, aligning with the principles of circularity where waste is transformed into valuable inputs for production.

Moreover, the profitability of the operation highlights the potential for scaling up recycling initiatives, which could increase economic returns while simultaneously strengthening the local scrap market. The scrap market serves as a key intermediary in this circular system, facilitating the flow of materials from consumers and informal collectors to formal recycling enterprises. As such, it not only contributes to environmental sustainability but also fosters economic opportunities for a wide range of actors, including waste pickers, cycle hawkers, and recycling businesses.

Overall, these economic indicators highlight that recycling not only promotes environmental sustainability by reducing waste and landfill pressure but also serves as a profitable venture. The positive profitability metrics underscore the feasibility of scaling up such operations, potentially generating greater income and strengthening the circular economy.

4. Conclusion

It is concluded that the scrap market in the study area largely depends on informal sector collectors, with cycle hawkers contributing 86.47% and waste pickers 7.32% of the total scrap. Small and unregistered firms typically purchase scrap from these collectors and sell it to large registered dealers, who further clean, package, and transport the materials to recycling companies. Firms pay taxes to the local government through contracts of local government before selling scrap nationally or exporting it international market.

On average, 2,223.54 tons of scrap are traded monthly, dominated by glass bottles (53.51%), metal scrap (18.99%), and paper scrap (18.80%). Monthly gross revenue reaches NPR 56,129.83 thousand, with net profitability averaging 6.13% and ranging from 5.62% to 20%, with paper scrap being the most profitable after Burnt engine oil. These economic indicators show that the scrap market not only supports environmental sustainability by reducing waste and landfill pressure but also represents a viable economic venture. Positive profitability in scrap market suggests shows the potential for strengthening the circular economy.

To further strengthen the sector, the local government should encourage the formal registration of informal collectors and small unregistered firms, which will improve social security, ensure traceability, and enhance their overall contribution in the sector. Providing registration numbers, maintaining systematic records, and supporting these actors to collect scrap from both urban and rural areas will help streamline operations. Additionally, government should revised their tax policy for scrap items and try to keep similar for each municipality to promote competitive business of scrap materials. Moreover, extending social security benefits to informal workers will significantly improve their welfare and promote a more resilient and efficient scrap value chain. Ultimately, these efforts will contribute to environmental sustainability and economic progress through strengthened circular economy practices. Additionally, training and awareness programs for community people to for promote waste segregation and recycling can boost overall circular economy outcomes by increasing more scrap quantity in the market.

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Authors' Contributions: The first and corresponding author solely conducted all research activities i.e., concept, data collecting, drafting and final review of manuscript and second author contributes for feedbacks ad correction in each steps of research and final review of manuscript .

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