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Circular Economy Models for Plastic Waste Management in Urban Slums

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Abstract: This study looks into the use of circular economy models for managing plastic waste in slums with informal waste systems. A community-based collection system blended with local entrepreneurial powered plastic valorization conduits alongside digital tracking tools forms the core of the proposed hybrid framework. Field surveys, stakeholder interviews, and a pilot study in some Indian slums were carried out as part of the India case study methodology. Increased recycling rates, improved livelihood, and greater environmental benefits were observed. The results demonstrate the efficacy of bottom-up inclusive circular approaches in dealing with plastic waste and socio-economic problems in underdeveloped urban centers and provide new pathways for waste governance disposals that are not dependent on top-level control.

Keywords: Sustainability; Circular Economy; Plastic Waste; Recycling; Community Participation; Slums; Informal Economy; Waste Valorization.

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I. Introduction

Every region struggles with waste management but the issue is even more acute in the fast-developing countries in the Global South. Slums tend to have a high concentration of people living in substandard houses without proper sanitation or clean running water. They are often left out from government services that help with things like collecting solid waste; as a result, they tend to have loads of garbage lying around on the streets and plastic waste fills rivers and lakes. In addition to the health risks from unclean public living spaces, this phenomenon also poses an obstacle to the functioning of a city and its ecological systems.

Top-down designs that rely heavily on an infrastructure system make it difficult for conventional waste management models to work in these contexts. However, CE approaches that emphasize mitigating the creation of waste through recycling and reuse provide a more suitable alternative for slum communities. CE promotes the idea of waste as an economic asset, capturing environmental, economic, and social value simultaneously. With regards to plastic waste, a circular approach can close the loop by turning waste into value through bottom-up, community-centric approaches.

Informal waste pickers and slum dwellers have always been and continue to be crucial actors in urban recycling systems, even though they work in harsh conditions. Integrating participants into more formal CE systems invites concepts of inclusive innovation. The scope of these innovations may be further boosted by the incorporation of digital technologies like blockchain traceability or mobile waste trading platforms.

This paper analyzes the incorporation of the circular economy model into slum regions with a focus on controlling the environmental menace posed by plastic waste. It assesses some of the plastics rejection activities, reviews literature relevant to the issue, and proposes a hybrid model based on community enterprises and local infrastructure which integrates collection, processing, and reuse. By addressing the dual focus on the environmental challenge and socially marginalized groups, it attempts to deliver on the twin challenge of waste management and urban poverty alleviation. It seeks to prepare a proposal tailored for decision makers including government, non-governmental organizations, and private businesses who are committed to building strong and just responsive systems of waste management.

II. Literature Survey

The blend of circular economy elements with informal urban settings has become a subject of focus for researchers in the past few years. One of the Velis, C. A., Hardesty, B. D., Cottom, J. W., & Wilcox, C. (2022). focused on the informal recycling market for slums in India and noted the importance of combining formal and informal systems. Their work documents the crucial role played by waste pickers in recovering plastics and proposes that cooperatives can be formed to improve income and operational efficiency.

(Sengupta et al,2022) They looked into the use of plastics in the circular economy in Southeast Asia, including the role of community-level sorting and upcycling which can exceed 70% recycling rates if market access and local leadership are available. They warn, however, that institutional support and sustained commitment is needed for scaling up.

(Gall et al, 2020) they analysed waste entrepreneurship in Nairobi's slums where micro-plastic waste to brick, tile, and furniture-melding enterprises were shown to function. The study highlights the need for adequate vocational training, microcredit, and policy aid.

(Velis,2017), they analysed the linking of waste collectors from slums to recycling firms in peri-urban areas with digital waste platforms. Mobile applications, according to the participants, make processes more visible and accessible which increases competition among middlemen, elevating prices for the sellers.

Also in this category, (Korsunova, 2022) designed a toolkit for increasing circular economy engagement for lower-income urban populations. It advocates for systems thinking including stakeholder co-design and life cycle analysis for eco and Economos stem viability.

III. Methodology

The circular economy model was designed through several steps of field research at the community level, starting from slum pilot projects in Delhi and Mumbai implementing bottom-up approaches. The first stage comprised of five slum cluster baseline surveys to understand waste flow – mapping active waste pickers and assessing the barriers to the recycling plastic-phenomenon. Systematic interviewing of local stakeholders such as residents and informal collectors, scrap dealers, and municipal officers was also done to quantify and qualify material volumes, income flows, and expose systemic blockages.

Relying on waste management as the focal issue, a decentralized model was tailored as aligned to enhance productivity through three components: plastic door-to-door collection by trained waste pickers, self-groups (SHGs) managed plastic aggregation hubs, and waste to value add micro enterprises. The a fore mentioned components are linked electronically through a mobile application to monitor the flow of plastics, payment transactions, and end-user participation.

The color-coded bags given to households for sorting was integral to the collection process. Waste pickers GPS logged their pushcart pickups, which were recorded through the app that offered fair payment according to weight and quality. Aggregation hubs, equipped with basic sorting and shredding equipment, were supplied with the plastic claws and processed them into flakes or pellets. These were sold to local manufacturers or, in-house, artisans crafted eco-products like planters, tiles, and packaging materials.

An impact evaluation was carried out over a six month period for recovery plastic rates, mean income per collector, and open dumping. A control area without the model was used for comparison. Data was collected on a monthly basis and analysed using descriptive statistics and comparative measures. Community feedback was gathered using focus group discussions in order to evaluate the social acceptance of the model and areas needing improvement.

IV. Results and Discussion

There was noticeable achievement in environmental, economic, and social aspects by applying circular economy model. In the intervention area, Plastic waste Recovery improved from an average of 15% in the

baseline period to 52%, a 246% improvement. There was an increase of 67% in households involved in source segregation which is encouraging community participation. There was also a 38% rise in the average monthly income of informal waste pickers because they had direct access to the markets and transparent weighing systems.

The open dumping and health risks associated with it were greatly reduced using the decentralized approach. Aggregation hubs are said to have, on average, processed 3.4 tons of plastic monthly, which was then used by three local product manufacturers. The digital platform that came with it ensured that there was real-time monitoring of the flow of plastic which significantly reduced leakages as well as ensuring timely payments to the collectors.

Table 1: Comparative Outcomes in Intervention vs. Control Areas

Indicator	Intervention Area	Control Area	% Change
Plastic Recovery Rate (%)	52	15	+246%
Avg. Monthly Income per Picker ($)	130	94	+38%
Households Practicing Segregation	480	287	+67%
Monthly Volume Recycled (Tons)	3.4	1.2	+183%

Table 2: Community Perception and Social Impact Assessment (n = 100)

Statement	% Agree
The system has improved neighborhood hygiene	91%
Payment methods are fair and transparent	87%
The model should be expanded to other slums	94%
Training was adequate and useful	89%

These results confirm that circular economy models, when adapted to the mechanics of an urban slum, can mitigate both environmental degradation and poverty simultaneously. On the other hand, sustaining the level of digital literacy, the consistency in plastic quality, and acquiring continued funding are some of the hurdles which can be faced

V. Conclusion

This research provides evidence on the efficiency and effectiveness of circular economy models revolving around the management of plastic waste in urban slums. The model's design encompassed community mobilization, digital technological solutions, and micro enterprise creation which cumulatively advanced emissions reduction, recovery of waste, job creation, and environmental concern

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