SOCIAL INCLUSION VARIABLES OF WASTE PICKERS THAT INFLUENCE REVERSE LOGISTICS

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Abstract: The scarcity of natural resources and the increasing waste generation pose significant global challenges, necessitating the adoption of measures to transition from a linear to a circular model. However, several barriers hinder this transition, many of which are influenced by actors involved in the reverse supply chain. Among these actors, waste pickers play a crucial role in reverse waste logistics, and their experience of social exclusion can impact the closure of the product cycle. This study aims to understand the social inclusion variables affecting waste pickers and their impact on reverse waste logistics. A systematic literature review, along with the snowballing technique and Causal Loop Diagram (CLD) tool, was conducted. The findings indicate that the living conditions of waste pickers, the conditions to carry out their activity, and government support are inclusion elements that act as leverage points to reverse logistics and ultimately affect the closure of the product cycle. This research contributes to a better comprehension of the feedback links between the social inclusion variables of waste pickers and reverse waste logistics performance.

Keywords: Waste Pickers; Social Inclusion; Reverse Logistics; Circular Economy; System Dynamics

Introduction

Increasing waste generation and resource scarcity have intensified the need for circular economy strategies capable of closing material loops. Reverse logistics plays a central role in this transition by enabling the recovery, reuse, recycling, and reintegration of post-consumer materials into productive systems.

Despite its importance, reverse logistics faces several implementation barriers (Demajorovic et al., 2014), including low collection rates, lack of awareness, technological limitations, and weak stakeholder integration. In many developing countries, waste pickers represent the backbone of recycling systems. Nevertheless, these workers often find themselves in several states of vulnerability and social exclusion (Ferreira et al., 2019; Sembiring; Nitivattananon, 2010), such as lack of remuneration policies, and other precarious living and working conditions (Almeida et al., 2017; Medina, 2000; Morais et al., 2022).

While literature has begun to link circularity with inclusion (Morais et al., 2022; Piao et al., 2023), there is a lack of understanding regarding the feedback mechanisms between social inclusion and reverse logistics performance. Therefore, this study addresses the following research questions:
RQ1: What are the key social inclusion variables affecting waste pickers?
RQ2: How do these social inclusion variables influence reverse logistics performance?

Theoretical background

Reverse logistics (RL) is essential for closing material loops in the circular economy. However, its implementation faces persistent challenges (Demajorovic et al., 2014), and some of the main barriers are highlighted in Figure 1. Waste pickers play a central role in overcoming some of these challenges, particularly in developing countries, where they are responsible for a significant share of recyclable material collection and sorting (Scarlat & Dallemand, 2019; Demajorovic et al., 2016). Despite their relevance, waste pickers frequently experience social exclusion, characterized by low income, limited access to education and healthcare, discrimination, and precarious working conditions (Morais et al., 2022; Almeida et al., 2017; Medina, 2000). Previous studies suggest that enhancing the social inclusion of waste pickers can increase their contribution to reverse logistics activities and support product cycle closure (Gutberlet et al., 2017; Morais et al., 2022; Piao et al., 2023). This relationship suggests the existence of feedback mechanisms that are suitable for investigation through a System Dynamics perspective.

Table 1 - Main reverse logistics barriers

Barriers	Description	Selected References
B1 - Low collection and recycling rate	Low waste collection and recycling rates limit material recovery and increase reverse logistics costs.	Ghisolfi et al. (2017); Guarnieri et al. (2016); Kadaei et al. (2023)
B2 - Lack of awareness	Limited public awareness leads to improper disposal, household storage of waste, and lower recycling rates.	Singh et al. (2020); Jang (2010); Castro et al. (2022); Derse (2024).
B3 - Technological scarcity	Limited availability and adoption of advanced recycling technologies hinder efficient material recovery.	Bressanelli et al. (2020); Demajorovic et al. (2016); Qu et al. (2019).
B4 - Lack of technical knowledge	Insufficient technical skills among stakeholders reduce the efficiency and quality of reverse logistics operations.	Shah et al. (2019); Meyer et al. (2017); Brkljac et al. (2024).
B5 - Illegal recycling market	Informal and illegal recycling practices divert waste from formal systems and increase environmental risks.	Ghisolfi et al. (2017); Demajorovic et al. (2016); Santos & Ogunseitan (2022)

Method

The research adopted a Systematic Literature Review (SLR) following PRISMA guidelines. The Scopus database was used as the primary source, employing the following search string: ("Waste picker*" OR "garbage collector*" OR "waste collector*") AND reverse AND logistics. The review process was complemented through backward and forward snowballing. After screening and eligibility assessment, a final sample of 69 articles was analyzed. Content analysis supported the identification of social inclusion variables, while Systems Thinking principles guided the development of a Causal Loop Diagram (CLD) representing the relationships between social inclusion and reverse logistics barriers.

Results

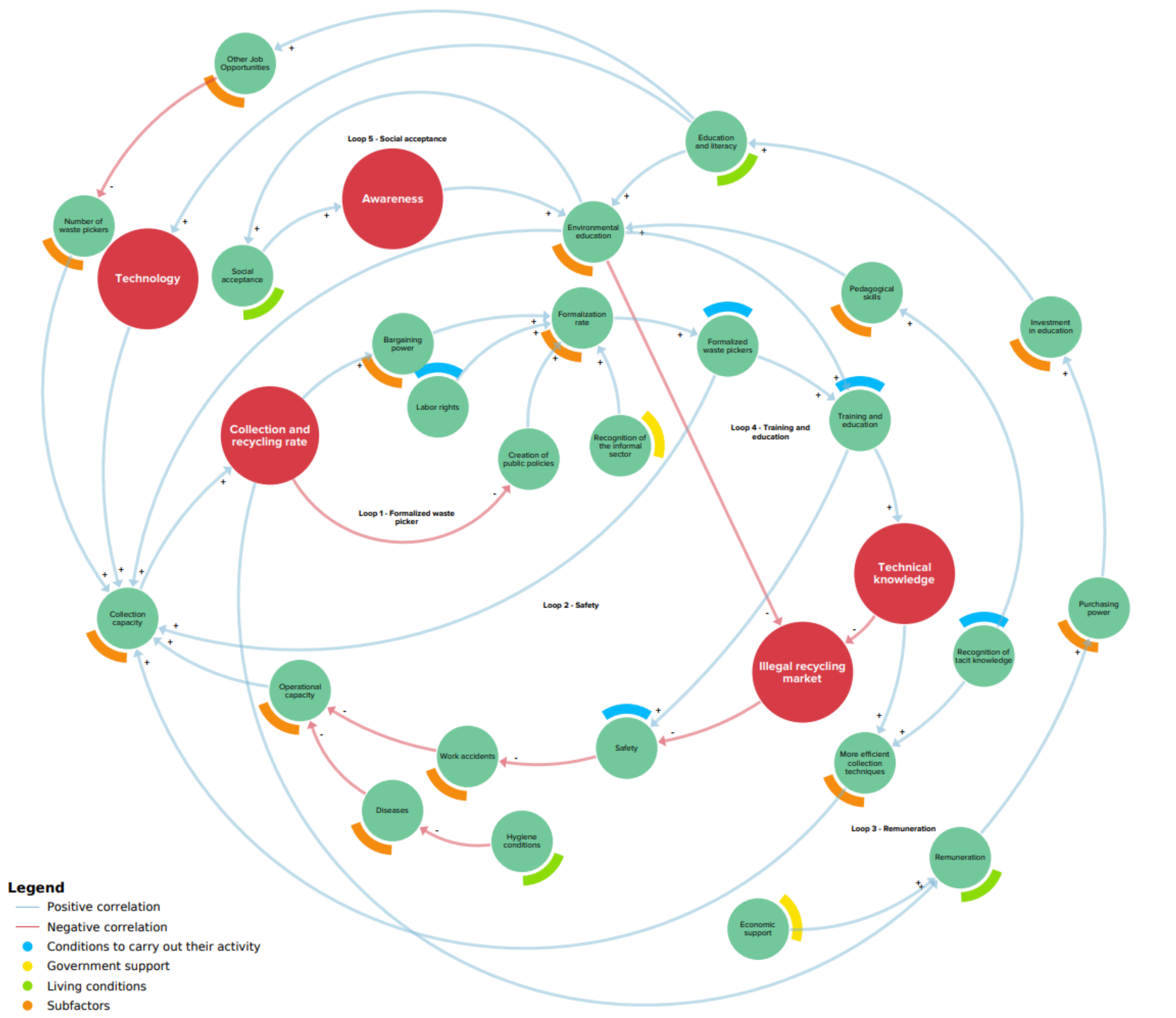
The analysis identified three categories of social inclusion variables (Table 2):

Table 2 - Social Inclusion Variables Identified in the Literature

Category	Variables	Description
Living Conditions	Education and literacy; social acceptance; hygiene conditions; remuneration	Influence waste pickers' quality of life and their ability to participate effectively in reverse logistics systems.
Conditions to Carry Out Activities	Safety; training and education; formalization; recognition of tacit knowledge; labor rights	Determine operational capacity and the effectiveness of waste collection and sorting activities.
Government Support	Creation of public policies; economic support; recognition of the informal sector	Create enabling conditions for formalization and long-term social inclusion.

The Causal Loop Diagram (Figure 1) revealed that social inclusion variables are strongly connected to reverse logistics performance through multiple feedback structures.

Figure 1 - Causal Loop Diagram



The analysis identified five reinforcing loops:

R1 – Formalization Loop. Formalization increases waste pickers' collection capacity through better infrastructure, transportation, and organizational support, improving collection and recycling rates (B1). Higher recovery rates strengthen bargaining power with municipalities and companies, attracting additional waste pickers to cooperatives and further increasing formalization. This reinforcing process also creates conditions for training and knowledge sharing, indirectly contributing to the reduction of the lack of technical knowledge (B4) and the illegal recycling market (B5).

R2 – Safety Loop. Improved safety reduces occupational accidents, increasing operational capacity and collection performance, which enhances collection and recycling rates (B1). Better performance strengthens bargaining power and encourages the formalization of waste pickers. Formalized workers gain greater access to training, improving technical knowledge (reducing B4) and discouraging participation in informal and illegal recycling channels (reducing B5). As illegal recycling decreases and working conditions become more organized, occupational safety improves further, reinforcing the loop.

R3 – Remuneration Loop. Higher remuneration increases waste pickers' purchasing power, enabling greater investment in education. Improved education enhances environmental awareness and collection effectiveness, increasing collection and recycling rates (B1) while also raising public awareness (B2). Higher recovery rates generate greater income for waste pickers, reinforcing remuneration. In the long term, better education also contributes to reducing the lack of technical knowledge (B4).

R4 – Training Loop. Training improves technical knowledge, enabling more efficient collection techniques and safer operations, directly reducing the lack of technical knowledge (B4). Higher operational efficiency increases collection and recycling rates (B1), strengthening bargaining power and encouraging formalization. As more waste pickers become formalized, access to additional training expands, reinforcing continuous learning and reducing dependence on informal recycling practices (B5).

R5 – Social Acceptance Loop: Greater social recognition of waste pickers increases public awareness (reducing B2), encouraging proper waste separation and disposal. This improves collection and recycling rates (B1) and increases the visibility of waste pickers' environmental contribution, which further strengthens social acceptance.

Discussion and conclusions

The findings show that waste picker social inclusion and reverse logistics performance are interconnected through reinforcing feedback mechanisms. The identified loops indicate that improvements in formalization, safety, training, remuneration, and social acceptance strengthen collection and recycling rates (B1) while also contributing to reducing the lack of awareness (B2), lack of technical knowledge (B4), and the illegal recycling market (B5). These results suggest that social inclusion variables are not only social outcomes but also influence reverse logistics performance by reinforcing positive changes throughout the system. Thus, this study contributes to understanding the systemic relationships between waste picker inclusion and reverse logistics through a System Dynamics perspective. Future research should convert the proposed Causal Loop Diagram into quantitative Stock-and-Flow models to evaluate alternative policy scenarios.

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