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HUMAN CAPITAL AND CIRCULAR ECONOMY: A TECHNICAL REPORT ON ACTIVE RECYCLING AGENTS (ARAS) IN SÃO PAULO

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Introdução
Brazil faces critical challenges in solid waste governance despite the PNRS (2010). Landfills are overcrowded and recycling targets unmet. Active Recycling Agents (ARAs) operate informally in peripheral neighborhoods, connecting waste to reuse but lacking policy support. Drawing on Lucas (1988), Mankiw, Romer & Weil (1992), and Nelson & Phelps (1966), this study frames human capital as key for eco-efficiency and circular transitions.

Contexto Investigado
This research adopts a microeconomic lens, linking production, waste generation, and recycling curves. Efficiency gains reduce waste and raise reuse. Human capital is central: Lucas (1988) stresses endogenous growth; MRW (1992) explain performance differences; Nelson & Phelps (1966) highlight technology absorption. Arrow (1962) adds learning by doing. Trained ARAs thus become crucial for advancing waste governance and circular outcomes.

Diagnóstico da Situação-Problema
The production function evolved to include human capital, R&D, and institutions (Lucas, 1988; MRW, 1992; Nelson & Phelps, 1966). Brazil's stagnating productivity (0.6% annually) reflects structural barriers: costly logistics, expensive energy, bureaucracy, and weak technical education. These constraints limit recycling efficiency. Workforce training (Pastore, 2004) empowers ARAs as system integrators, essential for PNRS goals but hindered by lack of formal recognition (De Paula et al., 2016).

Intervenção Proposta
A quantitative approach was applied with simulated data based on IBGE (2020) and ABRELPE (2022). A simple linear regression tested whether higher human capital predicts higher recycling rates across São Paulo municipalities. Five cities—São Paulo, Campinas, Santos, Ribeirão Preto, and São José dos Campos—were analyzed. Results suggest training and institutional support for ARAs raise efficiency in reuse, linking human capital directly to circular performance.

Resultados Obtidos
The proposed interventions align with the SDGs, generating multidimensional benefits: SDG 11 reduces illegal disposal and improves urban quality; SDG 12 fosters reuse and efficiency; SDG 13 cuts emissions via waste reduction; SDG 8 promotes decent work through ARA training and formalization; and SDG 17 strengthens partnerships among cooperatives, governments, firms, and NGOs. The regression model ($R^2 = 0.70$) shows that each 0.1 increase in human capital predicts a 10.5% rise in recycling rates across municipalities.

Contribuição Tecnológica-Social
This model strengthens the circular economy by empowering ARAs, improving coordination, and adopting simple technologies. Human capital is key: training enhances sorting, reuse, and connectivity, increasing both material value and social inclusion. Policy proposals include technical training, reuse centers, and fiscal incentives for cooperatives. Though based on simulated data, the results highlight the need for real municipal datasets. Findings confirm human capital as central to circular outcomes, aligned with PNRS and SDGs 11, 12, 13, and 17.

Palavras Chave
Solid waste management, circular economy, Environmental Governance