



A Novel Proposal for an Adapted Vehicle for Informal Waste Pickers in Ambato – Ecuador

Una Novedosa Propuesta de Vehículo Adaptado para los Recicladores Informales de Ambato - Ecuador

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RESUMEN

La gestión de residuos sólidos representa un reto para las ciudades contemporáneas porque implica varios niveles de gestión y procesamiento. En la base de la pirámide del reciclaje, se destaca el papel crucial de los recicladores informales, cuyo trabajo mejora las condiciones ambientales de las ciudades. A pesar de su valioso aporte, la informalidad ha marcado esta profesión, con condiciones laborales deplorables a nivel social y económico y baja seguridad laboral. Los recicladores recorren la ciudad en busca de la mayor cantidad de material reciclable posible, para luego venderlo y continuar la cadena. Sin embargo, llama la atención el proceso operativo de los recicladores debido a las inadecuadas condiciones, en términos de protección personal y movilización. Tradicionalmente, se desplazan con un carro, un producto destinado al transporte de cargas pesadas en distancias cortas. Sin embargo, es utilizado por los recicladores para recorrer largas distancias durante la jornada laboral diaria. A través de la metodología de validación temprana y continua para el diseño de productos, se propone un vehículo adaptado para el trabajo de los recicladores informales en la ciudad de Ambato. Muestra una valiosa visión de abordar la gestión de manera inclusiva, efectiva para la ciudad, con condiciones laborales adecuadas a nivel operativo para los recicladores.

ABSTRACT

Solid waste management represents a challenge for contemporary cities because it involves various levels of management and processing. At the base of the recycling pyramid, the crucial role of informal recyclers stands out, whose work improves the environmental conditions of cities. Despite its valuable contribution, informality has marked this profession, with deplorable working conditions at a social and economic level and low occupational safety. Recyclers roam the city in search of as much recyclable material as possible, so they can later sell it and continue the chain. However, the operational process of the recyclers is striking due to the inadequate conditions, in terms of personal protection and mobilization. Traditionally, they move with a cart, a product intended for transporting heavy loads over short distances. However, it is used by waste pickers to travel long distances during the daily working day. Through the methodology of early and continuous validation for product design, a vehicle adapted for the work of informal recyclers in the city of Ambato is proposed. It shows a valuable vision of addressing management in an inclusive, effective way for the city, with adequate working conditions at the operational level for waste pickers.

1. INTRODUCTION

Waste and solid waste, commonly known as garbage, are a ubiquitous reality in contemporary society. These products, generated by human activity, are considered useless, undesirable, or disposable, representing a global challenge of great concern.

Their value is practically nil for those who dispose of them, however, it has become one of the biggest concerns worldwide, due to its impacts on health, the environment, and the economy [1].

Large amounts of waste are a reality in both developed and developing countries, as they are propor-

tional to population growth and industrial progress [2]. Consumption rates increase solid waste production [3], due to the linear model of extracting, producing, using, and disposing [4].

Recycling represents an eminent option to reduce the negative externalities associated with the accumulation of waste and its improper disposal [5]. Waste pickers or waste collectors make up the base of the pyramid workforce in any informal recycling sector and will be an integral part of the circular economy of the global south in any realistic near-future scenario [6]. Waste management and recycling in these economies are characterized by a high degree of informality, so there is an urgent need to find models to partner with this sector in an effective, scalable, sustainable way [7], and socially inclusive [8].

The adjective "informal" refers to those workers who do not have labor rights [9]. In most cases, informal waste recycling is carried out by poor, disadvantaged, vulnerable, and/or marginalized social groups who often turn to garbage collection as an adaptive response to generate income [10].

In many developing and transition countries, the collection of recyclable materials from waste follows a complex process involving interconnected systems at different levels. In this context, the informal sector emerges as a fundamental element in the recycling cycle, being influenced by several factors such as the lack of government regulation, the economic opportunities available, the interaction with the industry, and the social characteristics of these areas. Overall, this involvement of the informal sector in the recycling process has a positive impact on the economic, social, and environmental aspects of the urban environment [8]. Increasingly, waste pickers are being recognized for their valuable contributions to sustainability and urban development. In cities without household collection or municipal recycling systems, waste pickers are important players in addressing the challenge of the growing amount of solid waste [11].

Waste collection is a kind of self-employment, or in turn it is part of a group of organized recyclers who form associations. In the studio "What Does It Mean to Have a Dirty and Informal Job? The Case

of Waste Pickers in the Rio Grande do Sul, Brazil" highlights that autonomy is essential to distinguish between waste pickers who work individually and those who work in organized groups. Individual workers have the freedom to manage their work according to their criteria, prioritizing daily subsistence and the sale of the materials collected. In contrast, waste pickers employed by organizations receive a regular salary and follow set schedules. While the workload of individuals depends on the amount of waste collected on the street, that of organized workers is largely determined by the volumes of municipal waste allocated to organizations through agreements with local authorities and waste pickers' groups themselves [12].

In many countries in the Global South, a significant proportion of waste collection activity is carried out by informal workers, whose work is not subject to state regulations or protected by law [13]. These individuals typically collect unwanted materials directly from homes, assorted public spaces, industrial facilities, commercial areas, or municipal waste disposal sites. Some waste pickers, especially those who have established cooperatives, also perform waste sorting functions in warehouses [14].

Within the national context, the study titled "Perspectives of Informal Street Waste Pickers in Loja, Ecuador" offers significant insights into the subject matter. Findings reveal distinct patterns in waste collection behaviors among genders, with men predominantly active during the night and women more active during the daytime. Moreover, individuals affiliated with waste picker associations demonstrate longer tenure in the recycling field compared to their independent counterparts. The study highlights that 59% of participants collect materials solely from streets, while 33% collect from streets and garbage containers, and 8% solely from containers. Notably, container collection points attract older individuals, while younger ones tend to roam the streets. However, it's concerning that neither the youth nor the elderly were observed to wear adequate protective gear such as boots, gloves, or coveralls. The vast majority of waste pickers sell their collected materials to city recycling centers, with only a minor fraction engaging with private recycling buyers [15].

In terms of working hours, waste pickers work be-

tween 3 to 4 days a week, with 4 to 8 hours a day. One of the main challenges they face is the need to travel as many streets in the shortest time as possible to collect material, which involves considerable distances carrying the materials. In addition, the majority of respondents are not affiliated with any association [15]. Compared to the study "Characteristics of Waste Pickers in Nakuru and Thika Municipal Dumpsites in Kenya" which mentions that waste pickers can work between 9 and 12 hours per day [16], it is possible to establish that in the national context it is equal to the working day of a formal job, while in Africa it exceeds 8 hours a day.

The main materials that are recycled are water or soft drink bottles, white paper, newspapers, cardboard [17], copper [16], iron, glass, aluminum, and e-waste [18]. The mobilization of recycled material is carried out, mostly, using carts, which are usually metal or wooden structures equipped with wheels to transport and load the materials. These carts are crucial instruments that significantly impact the physical work of waste pickers, as they influence the amount and variety of materials they can collect, as well as the distance they can travel to carry out their work [19].

In the study "Design and Construction of a Prototype of a Cargo Vehicle for the Use of the Informal Recycler - A Proposal for Medellín" it is mentioned that the cart used by the informal recyclers of the city is mostly built with wood, which has a bearing system that causes vibrations on the body of the operator when pushed or pulled on the pavement, as it lacks cushioning to absorb the energy generated during displacements [20]. The handling conditions and structure of the truck negatively impact the health of the recycler [21]. In most cases, the distances are long to travel and exhausting, as they move with the load of materials they collect while wandering [22]. Hidalgo-Crespo et al. (2023), in a study carried out in the Ecuadorian city of Guayaquil, mention that the greatest difficulty identified is that associated with the movement of recyclable waste and walking long distances. Therefore, the productive development of the sector depends on the skills, physical capacities and tools available to collect the largest amount of material in the shortest time [23].

In the study titled "Waste pickers and cities" [11]

highlights the importance of organization in improving the livelihoods of waste pickers and their integration into urban waste management systems. Examples from cities such as Belo Horizonte, Bogotá and Pune illustrate how waste pickers' organizations fight for access to and legitimization of waste as a resource for livelihoods. In addition, it demonstrates how waste pickers generate value for their urban communities. Municipalities across Latin America have responded to waste pickers' activism by embracing promises of inclusion, both economically and in healthy working conditions [22], [24].

In this context, where the work of waste pickers is crucial for urban sustainability in Latin American cities and given the imperative need to improve their working conditions, this document presents a proposal for a vehicle designed specifically for waste pickers in the city of Ambato. Based on industrial design principles, the main objective is to optimize your work, increase safety and efficiency in the collection of recyclable materials, while reducing the physical burden. This initiative seeks to improve the quality of waste pickers' work, increase their productivity, and contribute to the care of the urban environment.

2. METHOD

In this study, a comprehensive approach was adopted to address the development of a solution proposal to improve the sustainable mobility of informal waste pickers in Ambato. The process was structured in several stages, which are detailed below, along with tables that provide an overview of each phase and its results.

2.1. Definition of the Problem and Objectives

The first stage was to gain a thorough understanding of the mobility problem faced by informal waste pickers in Ambato. Interviews with waste pickers, field observations, and data analysis on working conditions and mobility constraints were conducted. The main objectives were to identify the specific needs and challenges of waste pickers and to establish clear criteria for the development of the mobility solution.

At this stage, an identification of the problem was carried out and clear objectives were established for the development of the mobility solution. Table 1 summarizes the measurable objectives set for the study.

Table 1.
Problem Definition and Aims

N°	Aims
1	Improve the process in the collection of recyclable materials.
2	Increase the safety of waste pickers during their journeys.
3	Promote the sustainability of the recycling process and reduce negative environmental impact.

2.2. Research & Analysis

A search was carried out using an existing typology analysis tool to identify best practices in sustainable mobility and product design aimed at social inclusion. Data on emerging technologies, innovative materials, and relevant case studies were collected. In addition, models adapted from Clientograma templates were used to gain an in-depth understanding of the needs and preferences of waste pickers, as well as the socioeconomic and environmental context in which they operate.

During this phase, data was collected on emerging technologies, innovative materials, and locally and internationally relevant case studies. Table 2 summarizes the key results of this phase.

Table 2.
Research and Analysis

N°	Research Findings
1	Best practices in sustainable mobility.
2	Emerging technologies and innovative materials.
3	Preferences and needs of informal waste pickers.
4	Socioeconomic and environmental context.

2.3. Ideation and Prototyping

Based on the findings of research and analysis, a phase of creative idea generation and prototyping was initiated. Controlled brainstorming sessions and participatory design workshops were conducted, using information collected from waste pickers. During this process, various mobility solutions were explored, from adapted vehicles to alternative transport systems, to identify the most promising concepts. Subsequently, conceptual, and functional prototypes were developed using 3D modeling tools and digital fabrication technologies. These prototypes were subjected to preliminary tests to gather feedback from users, the results of which are summarized in Table 3.

Table 3.
Ideation and Prototyping

N°	Ideation and Prototyping Results
1	Creative ideas generated.
2	Developed conceptual and functional prototypes.
3	Preliminary tests performed.
4	User feedback obtained.

Figure 1.
Prototyping of preliminary tests, own elaboration 2022



2.4. Prototype Development & Testing

Progress was made in the development of functional prototypes for the selected mobility solutions, using 3D modeling tools and digital fabrication technologies to create full-scale and full-size models. These prototypes underwent rigorous testing under

real-world working conditions, with the participation of recyclers, to gather feedback and feedback to improve both the design and functionality of the models.

Subsequently, the prototypes were evaluated according to predefined criteria, which included aspects such as ease of use, durability, safety, and efficiency in the collection of recyclable materials. Additional feedback was collected from users and iterative adjustments were made to refine the design and functionality of the mobility solutions. During this process, simplicity, accessibility, and sustainability were prioritized as fundamental aspects of the final design. Table 4 summarizes the results of this phase.

Table 4.
Evaluation of technical requirements

N°	Evaluation Criteria
1	Ease of use.
2	Durability.
3	Safety.
4	Efficiency in the collection of recyclable materials.

Figure 2.
Evaluation Criteria Design Proposal, own elaboration 2022



2.5. Evaluation and Refinement

The prototypes underwent a thorough evaluation based on predefined criteria, including aspects such as ease of use, durability, safety, and efficiency in the collection of recyclable materials. Iterative tweaks and refinements were made in response to

user feedback and results obtained during testing. In the final design of the mobility solution, simplicity, accessibility, and sustainability were prioritized. Once the development and refinement process was concluded, the mobility solution was implemented in close collaboration with local authorities and relevant community organizations. A continuous monitoring system was established to assess the impact of the solution and adjust as needed. Community participation in the management and maintenance of the mobility solution was actively encouraged. The results of this phase are summarized in Table 5.

Table 5.
Evaluation of technical criteria

N°	Evaluation results of technical criteria
1	Successful implementation of the mobility solution.
2	Continuous monitoring system established.
3	Active participation of the community in management and maintenance.

Figure 3.
Evaluation results, own elaboration 2022



2.6. Implementation and Monitoring

Once the development process was concluded, the mobility solution proposal was implemented at the simulation level. A continuous monitoring system was established to assess the impact of the proposal on the lives of waste pickers and adjust as needed to ensure its effectiveness at the project level. The

results of this phase are summarized in Table 6 (Appendix Table 6).

Figure 4.

Monitoring and adjustments, own elaboration 2022



3. DISCUSSION

The creation of a sustainable mobility solution for informal waste pickers in Ambato, merging industrial design with community needs, marks a significant step towards improving working conditions and efficiency in the collection of recyclable materials. The integration of these elements has generated a comprehensive proposal that effectively addresses the specific challenges faced by this vulnerable group.

The potential impact of this solution on the quality of life of waste pickers and the reduction of the environmental impact derived from waste management is seen as a key aspect in the discussion. It highlights the active participation of the community at all stages of the development process, ensuring the relevance and acceptance of the proposal. However, to ensure economic viability and long-term sustainability, a holistic approach involving various stakeholders, including local authorities and community-based organizations, is required.

4. CONCLUSIONS

This study highlights the value of the industrial design approach in solving mobility problems for informal waste pickers. The integration of this approach with the specific needs of the community has generated an innovative proposal that not only addresses mobility limitations but also improves working conditions and promotes environmental sustainability in Ambato.

The active participation of the community throughout the design process has been essential to ensure the relevance and acceptance of the proposed solution. However, to ensure its long-term viability, it is crucial to involve local authorities and other relevant stakeholders in the ongoing implementation and maintenance of the solution. This collaborative approach reflects industrial design's commitment to creating user-centered solutions that effectively respond to the real needs of the community. Ultimately, this research highlights the potential of industrial design as a powerful tool to promote more inclusive, equitable, and sustainable development in our cities.

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Appendix

Table 6.

Monitoring and Adjustments

N°	Follow-Up Process and Adjustments
1	Continuous evaluation of the effectiveness of the implemented solution.
2	Adjustments according to the needs and feedback of the users.
3	Ongoing community engagement and support.