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Solid waste management through participatory workshops and social innovation in the rural community of Cirminuelas (Tarija, Bolivia)

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The Cirminuelas sub-district is part of Tarija's 17th district and comprises five rural communities. It lacks urban sanitation services, resulting in open-air waste burning. This project aimed to promote sustainable waste management through participatory workshops based on community environmental education and challenge-based learning. The methodology integrated social innovation and horizontal dialogue, allowing facilitators and community members to build joint solutions by valuing local knowledge. The results highlight the transition from harmful practices to active community organization. The process included technical training in waste segregation and the transformation of waste into functional and decorative objects, providing a tangible solution to the problem identified in the diagnosis. As a result, environmental commitment was strengthened, and the foundations were laid for a self-managed community organizational structure. This study demonstrates that participatory training and the design of strategies tailored to the rural context are key tools for improving sanitation in areas where state infrastructure is limited, thereby ensuring the sustainability of social interventions in engineering projects.

Keywords: Solid waste; environmental education; social innovation; rural sanitation; participatory workshops; community management.

Gestión de residuos sólidos mediante talleres participativos e innovación social en la comunidad rural de Cirminuelas (Tarija-Bolivia)

La sub-central de Cirminuelas forma parte del distrito 17 de Tarija y agrupa a cinco comunidades rurales, carece de servicio de aseo urbano, lo que deriva en la quema de residuos a cielo abierto. El objetivo de este proyecto fue promover una gestión sostenible de residuos mediante talleres participativos basados en educación ambiental comunitaria y aprendizaje basado en retos. La metodología integró innovación social y diálogo horizontal, permitiendo que facilitadores y comunarios construyeran soluciones conjuntas valorando los saberes locales. Los resultados destacan la transición desde prácticas nocivas hacia la organización comunitaria activa. El proceso incluyó la capacitación técnica en segregación y la transformación de residuos en objetos funcionales y decorativos, brindando una solución tangible al problema detectado en el diagnóstico. Como resultado, se fortaleció el compromiso ambiental y se establecieron las bases para una estructura organizacional comunitaria autogestionada. Este estudio demuestra que la capacitación participativa y el diseño de estrategias adaptadas al contexto rural son herramientas clave para el saneamiento en zonas donde la infraestructura estatal es limitada, garantizando la sostenibilidad de las intervenciones sociales en proyectos de ingeniería.

Palabras clave: Residuos sólidos; educación ambiental; innovación social; saneamiento rural; talleres participativos; gestión comunitaria.

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1. Introduction

Solid waste is any waste other than human excreta; urine and wastewater are called solid waste. Solid waste can be classified into two types: biodegradable and nonbiodegradable (Water and Sanitation Program., 2012)

Solid waste management worldwide is still considered inadequate due to factors such as population growth, consumption patterns, production systems, and a lack of treatment or recycling options (Aguilar-Botia et al., 2023). This is particularly true in developing countries, where it represents one of the main institutional challenges, exacerbating the disparities between rural and urban areas. These disparities have implications for the allocation of municipal funds, the provision of adequate infrastructure, and the effective coverage of waste collection and disposal services.

Inadequate management of solid waste (SW) causes a range of harms to human health and the environment. For example, its disposal near residential areas contributes to illness among children and older adults, degrades the environment, contaminates water with leachate, and affects air quality through the gases and odours generated during decomposition (Aguilar-Botia et al., 2023).

In many rural communities, the lack of solid waste management means that rubbish is left near homes and water sources, buried or burned, posing risks to public health and the environment by spoiling the landscape and encouraging the spread of infectious vectors and diseases (Eraso et al., 2021). Rural residents face challenges of managing solid waste, including plastics and other products from modern products. Lacking awareness and tools, they often burn or dump waste unsafely. Some recover resources for income but use polluting methods, contributing to greenhouse gas emissions (Vinti & Vaccari, 2022)

According to data from the 2024 Census, in Bolivia, the most common method of household solid waste disposal is via refuse collection lorries; in urban areas, this method covers 65.2% of households, whilst in rural areas it accounts for only 7.4%. On the other hand, open-air burning of waste is a predominant practice in rural areas, accounting for 68.3%, compared to 27.6% in urban areas. (INE, 2024). In this context, Aguilar-Botia et al. (2023) state that the constraints in rural areas are mainly due to the difficulty of accessing dwellings because of the great distances between settlements, the scattered nature of the dwellings, and the lack of environmental management (Aguilar-Botia et al., 2023).

The Cirminuelas subcentral forms part of District 17 in the department of Tarija in Bolivia, which comprises five rural communities with a total population of approximately 843 inhabitants (Mendoza Gutiérrez et al., 2020). Through the VLIR-UOS project, the Bolivian Catholic University has been working with Transdisciplinary Learning Communities (TLCs) – known as ‘Cimirnuelas’ in the case of Tarija – which comprise six components, including the ‘Contribution to integrated water resource management’, intending to improve the quality of life in vulnerable rural and urban regions of Bolivia (Universidad Católica Boliviana Sede Tarija, 2020). As this is the area on which work has focused in recent years, it is the reason for the excellent communication and collaboration among the academic sector, the local council, and the communities. During visits to Cirminuelas since 2025 and based on interviews with residents, where solid waste management practices were identified, this locality does not have an urban waste collection service provided by the Autonomous Municipal Government. In the absence of such a service, the predominant practice for the disposal of household waste is open-air burning. This process produces ultrafine particles measuring 2.5 micrometres or less, which pose the greatest risk as they can be easily inhaled. The most common consequences include asthma, respiratory failure, etc. According to the World Health Organisation (WHO), these particles can pass through the lung barrier and enter the bloodstream, increasing the risk of developing cardiovascular and respiratory diseases, and even cancer (Brites, 2022).

Following discussions between stakeholders—community members and researchers from the aforementioned project— the following problem has been identified: inadequate solid waste management, a lack of awareness among community members regarding the dangers posed by open-air burning, and the importance of seeking solutions aimed at sustainable rural development. The initial goal is to raise awareness of this issue, which is causing environmental degradation and exacerbating the climate crisis. The research question formulated as a result was therefore: How do participatory environmental education workshops on proper solid waste management influence the reduction of open-air burning in the community of Cimirnuelas, Tarija?

Furthermore, social responsibility requires institutions to promote sustainable growth through a modern approach that integrates nature and the population. This entails qualities such as excellence in work, respect for and appreciation of the environment, all for the benefit of the community – treating it as part of the problem so that it can subsequently become part of the solution – and this is achieved through training in environmental education (Durand Machicado, 2023).

Based on the hypothesis set out above, participatory environmental education workshops aimed at residents of the Cimirnuelas community will significantly reduce the frequency of open-air burning of household waste and increase awareness of, and adherence to, appropriate solid waste management practices. On that basis,

Participatory workshops have been proposed, based on the participatory action methodology, with the aim to promote sustainable waste management practices, with a focus on sorting, reusing, and recycling. This project adopts a social innovation approach centred on community participation and empowerment throughout the intervention process. This approach promotes the co-creation of solutions through participatory workshops and deliberative processes that incorporate the experiences and needs of community members. In this way, the methodology can be replicated at different scales, whilst also providing a database for future studies.

Participatory Action Research is a process through which members of a community collect and analyse information and take action to address their problems with the aim of finding solutions and promoting political and social change. Participants, regardless of their level of education or social status, play an active role in the research process, which recognises that the experience of everyone involved is valuable and enables them to contribute to the process (Balcazar, 2003).

2. Objectives

Promote good solid waste management practices through participatory environmental education workshops, to reduce open-air burning and contribute to sustainable rural development in the community of Cirminuelas, Tarija.

3. Methodology

In carrying out this study, the Participatory Action Research (PAR) methodology was applied, which prioritizes direct engagement and contact with the individuals or communities involved, with the explicit aim of bringing about concrete changes to a specific problematic situation (Requena Bolívar, 2018a). The research process enables the community to learn how to conduct research and to appreciate the role that research can play in their lives. IAP participants learn to understand their role in transforming their social reality, as key players in the process of change (Balcazar, 2003).

In this case, the research took the form of participatory workshops, which, within the methodological framework of popular education, serve as a tool for working with groups; they are time-limited and goal-oriented. This sets in motion an educational process based on the

integration of theory and practice, the active involvement of participants, the exchange of knowledge, and the collective generation of learning, underpinned by the principle of 'learning by doing', which brings about a simultaneous transformation in both the individuals involved and the initial situation (Cano, 2012). This methodology not only strengthens collective empowerment but also makes the model replicable and scalable, allowing it to be adapted to other contexts facing similar challenges, see figure 1.

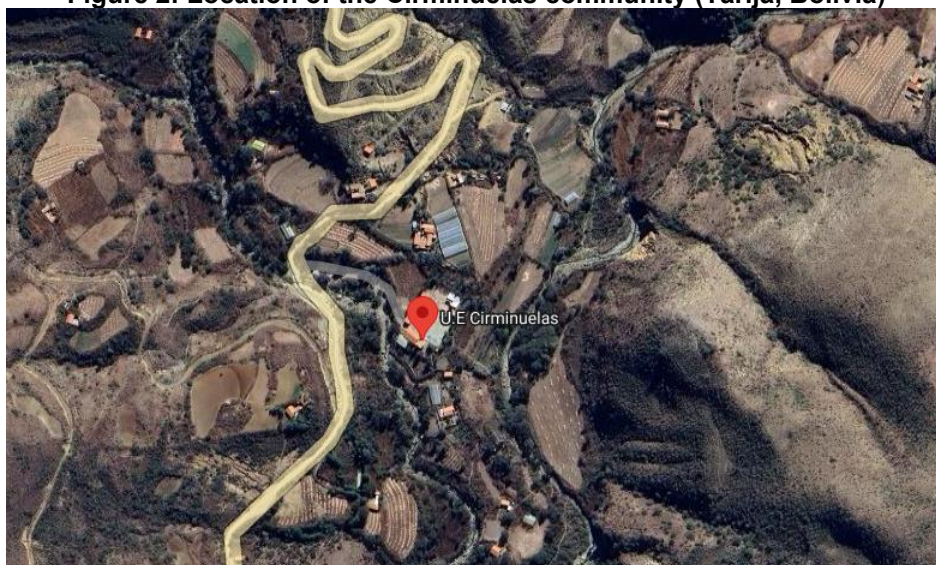


Source: Compiled by the author

The study area corresponds to the community of Cirminuelas, located in District 17 of the municipality of Cercado, in the department of Tarija. This village is situated approximately 32 km north of the city of Tarija (Figure 2).

Their main economic activity is agriculture; they practice annual crop rotation with the aim of maintaining and improving soil fertility. Their main source of income comes from selling their crops at the Tarija market, where producers promote the adoption of agroecological and organic practices, avoiding the use of synthetic pesticides and chemical fertilizers. Among the most representative crops is amaranth, a pseudocereal of high nutritional value (Alba Leyton & Rivera Chacón, 2020)

Figure 2: Location of the Cirminuelas community (Tarija, Bolivia)



Source: Google Maps

It is worth noting that work had previously been carried out in the community to collect technical data—on water quality and quantity, and soil quality—to obtain clear and accurate information on resource use within the community. In addition, activities were initiated and concluded with participatory workshops. These initiatives have been useful in identifying the community members' level of knowledge regarding water and sanitation management and reaffirm the

commitment of those seeking to transform their social reality, as well as the practical value of action research with social groups or communities.

The workshops focused on the involvement of women, community leaders, and young people, recognizing them as key players in social dynamics, their participation in day-to-day farming practices, and their potential as agents of change in social innovation processes. In addition, students from the Bolivian Catholic University of San Pablo were involved, taking on the role of facilitators, as a significant proportion of the community members had low levels of literacy. It is important to note that this was a qualitative case study only, intended for local application.

The activities were organized into three phases: assessment, implementation, and evaluation.

3.1 Diagnostic phase

During the diagnostic phase, surveys, participatory dialogue with community leaders and direct observation during a participatory workshop were used; this enabled the identification of current solid waste management practices, the level of environmental awareness and the community's perception of the issue. This participatory assessment serves as a strategy for understanding the current state of solid waste management by incorporating technical activities aimed at gathering information on the volume, characteristics and current practices of solid waste management.

The surveys covered the following areas:

- General information about residents.
- Sociodemographic characteristics (age, gender, number of inhabitants, basic services, and main economic activity).
- Estimates of the quantity and type of waste generated in each household.
- Common waste management activities and practices
- Level of knowledge regarding the sorting, reuse, and recycling of materials.
- Knowledge of hazardous waste and composting practices.
- Perception of the waste problem within the community and willingness to adopt changes.
- Commitment to implementing good practices and generating by-products.

3.2 Implementation phase

During the implementation phase, participatory workshops based on the 'learning by doing' approach were organized in accordance with the principles of the IAP. The theoretical presentation took the form of a dialogue and was supported by visual aid (informative banners, contextualized examples). During this session, the definition of solid waste according to the regulation was presented, followed by a discussion of the basic classification of waste into five categories: organic, recyclable, non-recyclable, hazardous, and special. The hierarchy of solid waste management was then explained, highlighting the order of preference that prioritises the actions of refusing, reducing and reusing, with particular emphasis on the most accessible and low-cost options provided for under Law No. 755 (GIRS). (Ley N° 755 de Gestión Integral de Residuos, 2015). The session also explored the health and environmental impacts of open-air burning, detailing pollutant emissions and their link to respiratory and cardiovascular diseases, as well as cancer. All of this was accompanied by informative banners, which were left at the school as a reminder (Figure 3).

Figure 3: GIRS information banner



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vltiruos
sharing ideas, changing lives

TALLERES PARTICIPATIVOS: MANEJO Y REUTILIZACIÓN DE RESIDUOS SÓLIDOS

Elaborado por: Patricia Marcela Rocha Peducasse
Supervisora.: María Alejandra Leigue Fernández

Clasificación de los residuos sólidos

Orgánicos: Verde para aquellos que provienen de los restos de plantas o animales; por ejemplo: cáscaras de frutas, cáscara de huevos, etc., también los que provienen de actividades agrícolas y pecuarias (estiércol, rumen, etc.)

Reciclables: Materiales que pueden ser reprocesados.

- Amarillo para plástico, metal
- Azul para papel y cartón

No aprovechables: Verde para materiales que no tienen potencial de ser reciclados o compostados y que requieren disposición final.



Jerarquía de los residuos



Consecuencias de la quema de basura

La quema de residuos, como plásticos, cauchos y basura, libera gases y partículas tóxicas que contaminan el aire y afectan la salud humana, causando irritación ocular, problemas respiratorios y enfermedades crónicas. También daña cultivos y suelos, genera malos olores, reduce la biodiversidad, aumenta el riesgo de incendios forestales y contribuye a la crisis climática.



¿Qué podemos hacer?

- Separar residuos reciclables (plástico, metal, vidrio).
- Reutilizar envases para macetas, contenedores o artesanías.
- No botar aceite al suelo ni al río.
- Compostar restos orgánicos para mejorar nuestras chacras.
- Depositar los residuos en puntos de acopio autorizados.

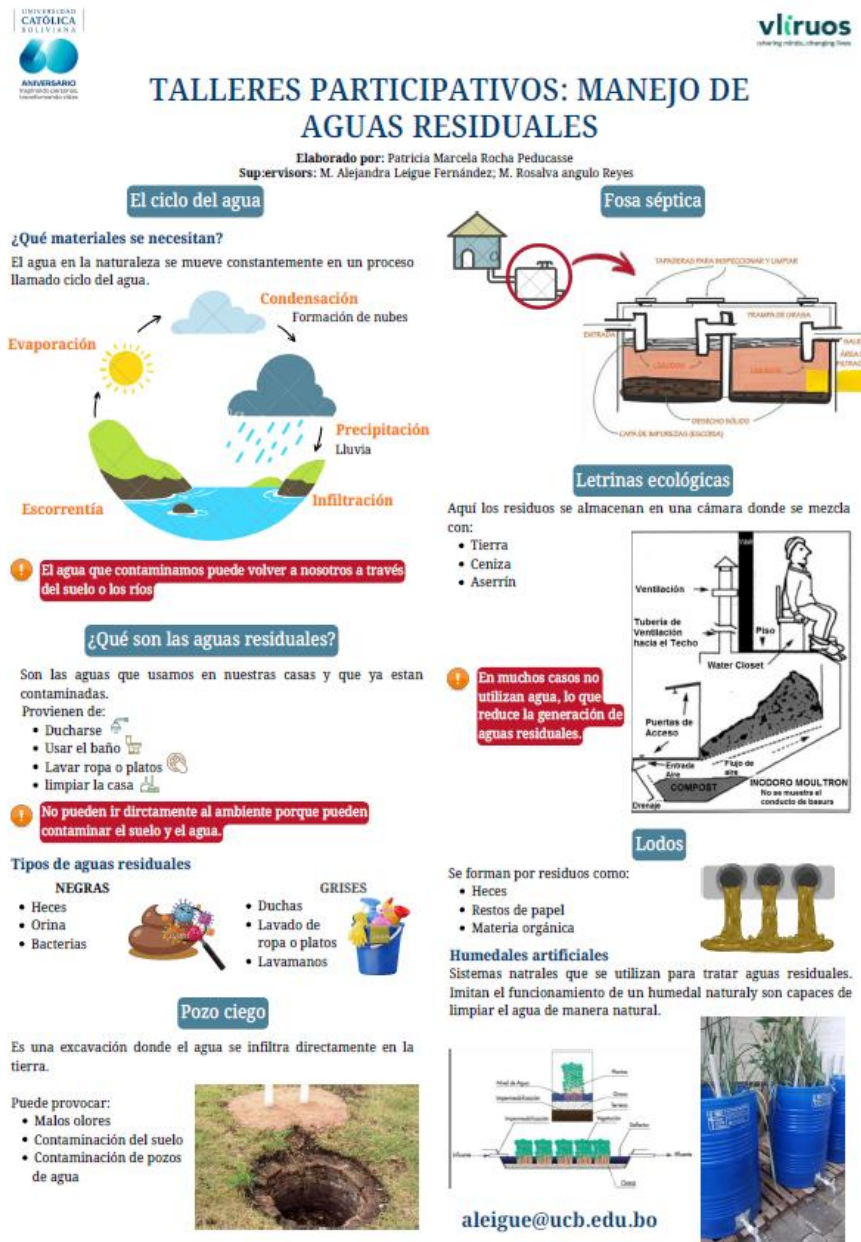
¿Qué se puede reciclar?	¿Qué no se puede reciclar?
Papel y cartón: Papel blanco, periódicos, revistas y libros, hojas sin plastificar, cartones y sobres y folders. Vidrio: Frascos de alimentos, botellas y vasos. Plásticos: Frascos, botellas, bolsas plásticas y bolsas de baja densidad.	Pañales y servilletas desechables (como papel), papel celofán, papel fax, curitas, papel plastificado. Parabrisas y faros, focos, lentes, espejos, pyrex. Bolsitas de frituras, plumas plásticas, nieve seca, radiografías, platos y cubiertos desechables usados, tetrabrik.
Metales: Aluminio puro: Latas de refresco y conserva, cervezas y otras bebidas, utensilios, de cocina, marcos de puertas y ventanas, partes de motor. Aleaciones ferrosas: Acero y chatarra sin aluminio.	Papel aluminio, mezclas de aluminio con hierro o con cobre.

“La tierra no es una herencia de nuestros padres, sino un préstamo de nuestros hijos”

Source: compiled by the author based on (Ley N° 755 de Gestión Integral de Residuos. , 2015)

In addition, the topic of wastewater was addressed, distinguishing between greywater and blackwater; this was done to highlight the close relationship between wastewater and solid waste, as the improper disposal of solid waste can generate leachate that contaminates water sources and exacerbates the organic and microbiological load. As in the previous workshop, informative banners were displayed and remained at the school (Figure 4).

Figure 4: Information banner on basic sanitation



Source: compiled by the authors

In addition, practical activities were carried out; these formed the core of the immediate application of the concepts presented and were designed to be replicable. Firstly, participatory land mapping group work was carried out, in which community members drew a schematic diagram of their homes and immediate surroundings, locating their wastewater disposal system, water supply, solid waste burial/incineration area, storage tanks, and cultivation areas, to visualize proper waste management and prevent cross-contamination.

A second activity organized by “Water and Sanitation Clock” involved identifying the times of day when community members use water, illustrating this on a clock; this helped to identify patterns in wastewater generation and their link to solid waste disposal practices.

This was followed by a practical session on the reuse and recovery of waste, during which the process of making an eco-brick and its various uses were demonstrated, supported by a leaflet.

As a closing activity, participants collectively made eco-friendly soap from used cooking oil, with an explanation of the saponification process (see Figure 5). All these activities were carried out in groups and collaboratively, with the guidance of facilitators and the support of visual aids, ensuring the exchange of knowledge and the direct adoption of the techniques by the community members attending the workshops.

Figure 5: Flyers promoting waste reuse practices



Source: compiled by the authors.

3.3 Evaluation phase

This phase was designed as a participatory, multi-stakeholder, and capacity-building process to assess both the immediate results and the transformative processes generated within the community. It began with a collective group discussion in which participants analysed the water usage maps and timetables, identifying lessons learnt and potential improvements in the integrated management of solid waste and wastewater. As Balcazar (2003) remarca la importancia de enseñar a la gente a descubrir potencial para actuar, liberándoles de estados de dependencia pasiva previos y llevarlos a comprender que la solución está en el esfuerzo que ellos mismos puedan tomar para cambiar el estado de las cosas (Balcazar, 2003)

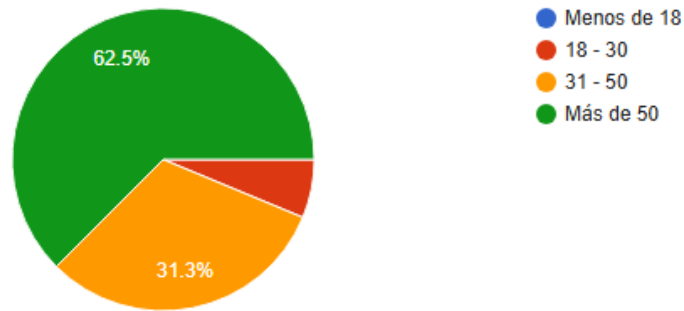
The evaluation also included systematic observation during the activities, an assessment of the level of active participation, and the systematisation of the narratives and commitments expressed. Through this phase, we were able to complete the spiral cycle of the IAP, document the impacts achieved, and generate inputs for future follow-up actions and the scalability of the intervention. As Cruzado Marín (2023) points out, the Action Research approach prioritises the needs and perceptions of stakeholders, using qualitative tools such as semi-structured interviews, surveys and secondary data for analysis, with the majority of the community showing a willingness to participate and cooperate, recognising their key role and actively engaging to improve the current waste management situation (Cruzado Marín, 2023).

Finally, in line with Cayetano Morales et al (2026) the evaluation has shown that the combination of participatory approaches, context-specific content and active learning methods has the potential to foster a strong sense of environmental awareness within the community; however, for this initiative to have a lasting impact, it will be necessary to continue running the workshops, involving local authorities and strengthening institutional capacity for waste management (Cayetano Morales et al., 2026)

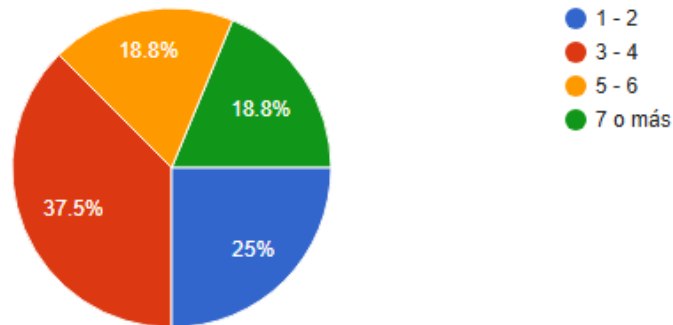
4. Results and discussion

The key findings from the workshops are outlined below. The surveys yielded the results shown in Figure 6.

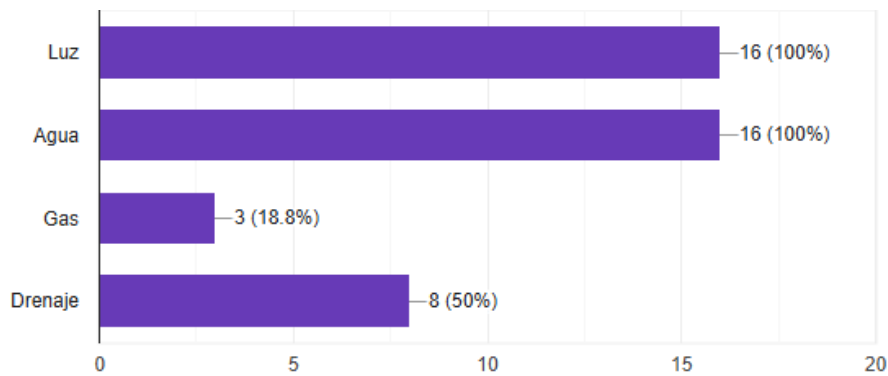
Figure 6: Survey results and analysis



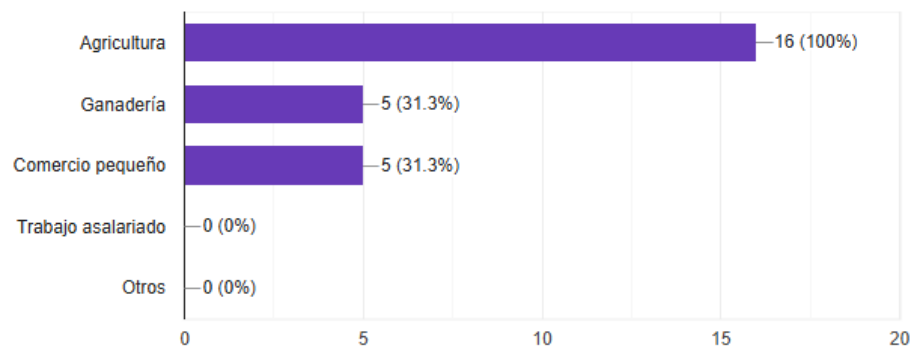
A) Age group of the participating community



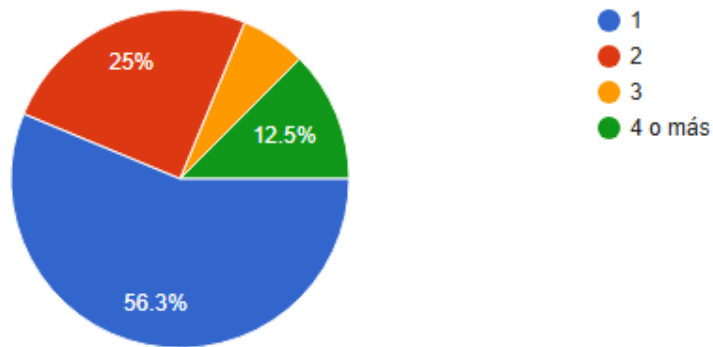
B) Number of people living in your household



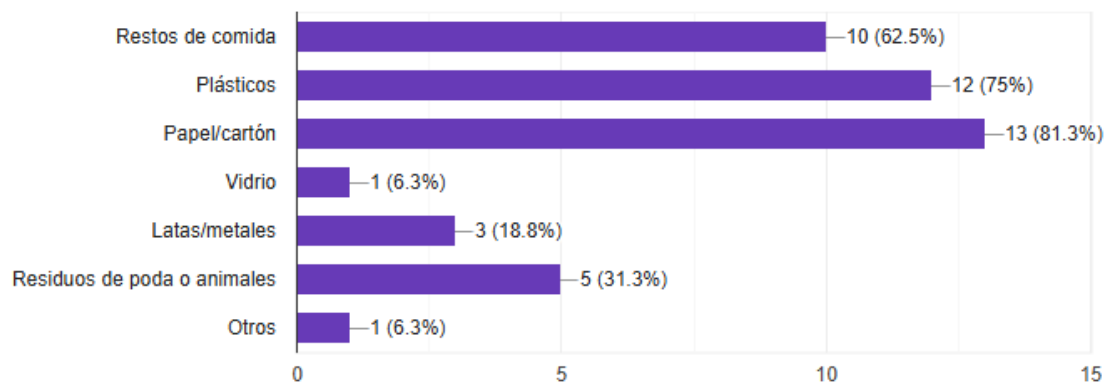
C) Services available in your home



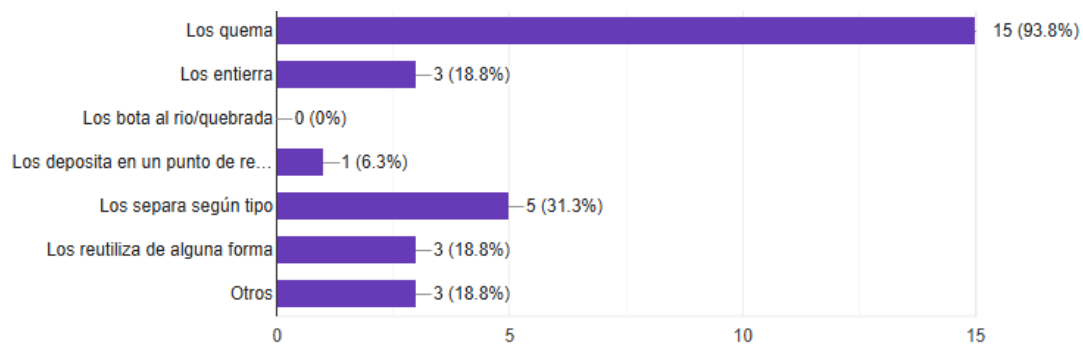
D) Main economic activity



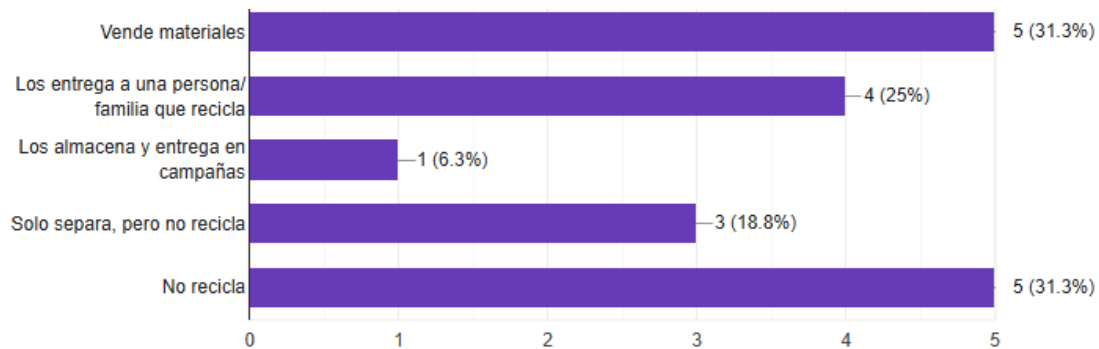
E) Estimated number of bin bags you throw away each week



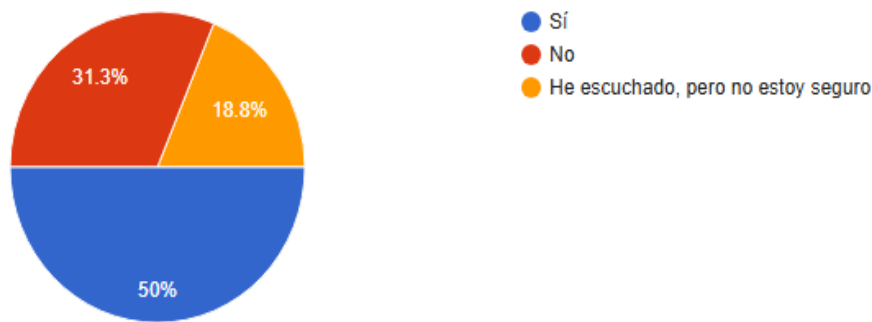
F) The types of waste you generate most frequently



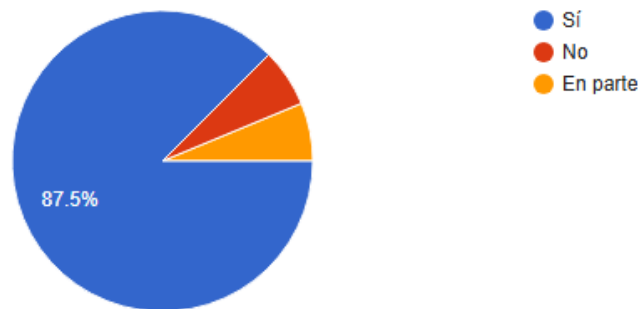
G) Disposal of waste generated



H) Recycling your waste



I) Do you know what hazardous waste is?



J) Do you think waste is a problem in your community?

The surveys confirm that the workshops saw a higher participation rate among adults over the age of 50, at 62.50%, and that the number of people per household is predominantly between 3 and 4. This confirms the current situation in these types of communities, which are remote from urban centres, where younger people migrate to capital cities and/or other countries such as Argentina, in search of better opportunities, whilst the older generation remains behind and carries on with their daily lives. According to the results, it is evident that everyone is engaged in agriculture, with a smaller number involved in livestock farming and small-scale trade. As for basic services, 100% have electricity and tap water, 50% have drainage systems, and 18% have liquefied petroleum gas.

Regarding waste management, the majority (56.30%) generate one bin bag per week, which can weigh between approximately 3 and 5 kg; the exact quantities were not quantified on this occasion. A large proportion of this waste consists of food scraps, plastics and paper/cardboard, with a smaller proportion comprising garden waste and animal waste. Over 90% burn their waste, 31% sort it, and some bury it or reuse it in some way. The fate of the waste varies: some sell it, others do not recycle at all, others hand it over to people who recycle it, some simply sort it, and a few store it and hand it over during collection campaigns. 50% are aware of hazardous waste, and in summary, 87.50% consider waste to be a problem in their community due to the lack of an adequate collection and disposal service.

During the implementation phase, the involvement of key stakeholders—community members, university students, and facilitators—in the various participatory and collaborative practical activities is highlighted, as shown in Figure 7. As Cayetano Morales et al. (2026) point out, participatory methods enable the integration of local and scientific knowledge to develop more legitimate and context-specific solutions, particularly in areas where waste management has historically been weak.

Figure 7: Workshop activities and participants



Source: compiled by the author

During the evaluation phase, it was found that participatory workshops can motivate participants to take various actions to protect their health and the environment, particularly by preventing the burning of non-recyclable waste. As Requena (20218) said, training using the IAP approach fosters the awareness needed for active and committed participation in

collectively planned activities aimed at solving environmental problems (Requena Bolívar, 2018b).

The workshop on making handmade soap was very well received by everyone, and there is now a desire to improve these kinds of by-products so that they can be of practical use to them. The demonstration on making eco-bricks helped them to explore alternatives for disposing of single-use plastics and waste that cannot be recycled and emit toxic gases when burned.

Overall, there was a good level of participation from community members, demonstrating a genuine interest in caring for the environment, health, and the local area. As highlighted by Vinti & Vaccari (2022), these activities can improve local conditions from a social, environmental, and health perspective; furthermore, they can have an impact on tackling environmental pollution (Vinti & Vaccari, 2022).

Most community members follow good waste management practices because they need to dispose of their waste, but above all because they are aware of the harm that improper waste management can cause to both health and the environment; they have realised that burning non-recyclable waste is a last resort. This supports the findings of Erazo et al. (2021), who note that rural communities often lack the resources to adopt new technologies for utilising waste materials (Eraso et al., 2021).

About the management of wastewater and septic sludge, they expressed an interest in using wetlands for treatment and in utilising the sludge as compost, adding it to their compost heaps alongside the organic waste and animal manure they currently use. This was confirmed by the results of the “Water and Sanitation Clock” and “Earth Map” activities, reaffirming what was stated by Cayetano Morales et al (2026), environmental education lays the foundations for a cultural transformation that enables us to tackle environmental issues more effectively (Requena Bolívar, 2018b).

At the end of the workshops, the enthusiasm and cooperation of the students and facilitators were evident, as they patiently explained the aim, methodology, and outcomes of each activity to the community members using simple language and visual aids, thereby highlighting the value of teamwork. In line with the recommendation made by Durand Machicado (2023), people should be trained using plain language and audiovisual materials so that they understand the importance of, and the significant link between, solid waste management, environmental conservation, and social responsibility (Durand Machicado, 2023).

Finally, it should be noted that visits to the community of Cirminuelas will continue, to follow up on the outcomes of the workshops with a closing event, thereby enabling us to assess the success or effectiveness of the workshops—particularly in terms of reducing open-air waste burning—and to compare these results with similar initiatives in other regions of Latin America.

5. Conclusions

This study demonstrated that the use of participatory workshops based on the IAP approach, combined with the application of popular education, constitutes an effective and replicable strategy for addressing issues of community interest; in this case, the challenge of solid waste management in a community with a low level of literacy.

In the community of Cirminuelas, the project fully achieved its objectives: to assess the current situation in the area and identify prevailing practices, which revealed that open-air burning accounted for 93.8% of cases, alongside a low rate of waste separation and reuse; practical alternatives for reuse and recovery were also introduced, directly addressing local needs and resources.

The combination of theoretical input with practical activities, such as making eco-bricks or collectively producing eco-friendly soap, led to the community taking ownership of low-cost

sustainable techniques. Furthermore, the active involvement of women and community leaders, supported by university students acting as facilitators, demonstrated the transformative potential of social innovation to strengthen collective empowerment, foster the exchange of knowledge, and facilitate the transition towards more responsible practices in solid waste management and basic sanitation.

The results suggest the importance of continuing the workshops, involving local authorities, and maintaining family participation until institutional capacities in waste management are strengthened, thereby contributing to the development of a more informed environmental culture geared towards sustainability.

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Use of generative artificial intelligence

No generative artificial intelligence was used to prepare this paper.

Communication aligned with the Sustainable Development Goals

