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Utility Model for Climate Change Adaptation at El Bosque University: Circular Economy Approach to Paper and Cardboard Waste

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Abstract. The impact of climate change has intensified the urgency of adopting sustainable practices in academic institutions, highlighting the need for innovative models that not only mitigate environmental impact, but also promote effective adaptation. This paper presents a pioneering approach focused on the development of a utility model designed specifically for climate change adaptation in the context of Universidad El Bosque. The paper focuses on the implementation of circular economy strategies, focusing on the efficient management of usable waste generated at the institution, specifically for cardboard and paper. This model, the result of interdisciplinary research, not only proposes tangible solutions to reduce the university's carbon footprint, but also establishes an exemplary paradigm for other educational institutions on their path towards environmental sustainability. In the development of the research and analysis of the data recorded by the Environmental Management Unit, it is determined that the rate of generation of usable waste from the university corresponds to a total of 19,475 kilograms for the 2023 period. Therefore, through the detailed analysis of the implementation and results obtained, this article seeks to contribute to the advancement of knowledge in a useful model for adaptation to climate change, with a practical and replicable approach in university environments and beyond, which consists of proposing a model for the implementation of a process of transformation of cardboard and paper waste, for the production of stationery items that can be sold in the university store, promoting reuse, circular economy and sustainability.

Keyword:

Circular economy, sustainability, climate change, waste.

1. Introduction

In the 21st century, we face unprecedented environmental challenges arising from climate change, which demand innovative and sustainable responses. Educational institutions, as crucial centers of knowledge generation, play a vital role in finding solutions to mitigate and adapt to these global challenges. This article dives into the convergence of technological innovation and environmental management by presenting a utility model designed for climate change adaptation in the specific context of a university. We focus on the implementation of circular economy strategies, specifically on the efficient management of usable waste generated daily in the institution.

Climate change has become an undeniable reality that affects every corner of the planet. Academic institutions, as cradles of knowledge and agents of change, must assume a leadership role in the adoption of sustainable practices. The university environment, with its complex web of activities including research, teaching and administration, is a significant source of emissions and waste. Against this backdrop, there is a pressing need to develop innovative approaches that not only reduce the environmental footprint, but also strengthen the resilience of the university in the face of climate change (Marrero, 2019).

In this context, waste management emerges as a critical component of an institution's sustainability strategy. Waste production, in particular, offers a unique opportunity to implement circular economy strategies, where waste is considered valuable resources and is integrated back into productive cycles. The importance of environmental management, specifically focused on waste, lies in its ability to reduce the negative impact of university activities on the surrounding environment, while promoting efficiency and accountability (Corzo, 2021).

On the other hand, it is imperative to mention that the circular economy, fundamental to the proposed utility model, is presented as an essential paradigm in waste management. Unlike the traditional linear model of "use and dispose", the circular economy seeks to minimize waste and maximize the value of products, materials and resources. In the university context, this implies the implementation of strategies that go beyond conventional recycling.

Accurate classification of waste into categories such as recyclable, reusable and compostable becomes a crucial starting point. The installation of selective collection systems, awareness-raising among the university community and collaboration with specialized external companies are fundamental aspects of this process. In addition, the creation of closed production loops, where recycled materials are reintroduced into the supply chain, completes the cycle and maximizes resource efficiency.

Finally, the utility model not only contributes to environmental sustainability through waste management, but also strengthens the university's resilience to climate change. Efficiency in resource management and the reduction of emissions derived from waste production and disposal are key aspects in the adaptation of the institution to a constantly changing environment (Calderón, 2023).

Proper waste management also plays an essential role in preventing soil and water pollution, thus preserving natural resources in the university's surrounding environment. This not only benefits the institution itself, but also contributes to the protection of biodiversity and the health of the local community.

2. Theoretical Approach/Methodology/Scenario

2.1 Objective

Design and discuss a utility model for the supply, processing and production of recycled materials for the sale of products in the university store of Universidad El Bosque.

- Conduct a diagnosis of the generation rate of usable cardboard and archival paper waste at the university.
- Investigate the needs and demands for sustainable products by the university community, through surveys and analysis of results, to identify preferences and current trends in terms of recycled products.
- Propose a utility model that considers aspects such as production and marketing, in order to ensure the long-term sustainability of the project and its contribution to the development of the university store.

2.2. Methodology

The development of the utility model for the supply and recycling of paper and cardboard for the sale of stationery products in the university store of Universidad El Bosque, consists of a mixed method, where the methodology proposed for the project consists of several key stages to achieve the specific objectives established. First, a comprehensive analysis of the amount of usable waste generated at the university by the year 2023 will be carried out. This analysis involved the collection and evaluation of data on the amount and type of waste generated in different areas of the campus, using methods such as periodic sampling and analysis of waste management records, which is carried out by the Environmental Management Unit on a monthly basis.

In addition, it is important to mention that within the institution, there are specific bins for the storage of archival paper in each of the floors and administrative areas of the institution, as well as a cardboard storage area, located at the transfer point or in the main solid waste warehouse, which consists of reused containers, where there is currently a compactor for the processing of cardboard and plastic.

Once the analysis is completed, the needs and demands for sustainable products among the university community will be investigated. This will be accomplished through surveys and analysis of results designed to identify current preferences and trends in recycled products. The surveys will be distributed to students, faculty, and administrative staff, and will address issues such as willingness to pay for sustainable products, preferences, and the types of products most in demand.

To calculate the survey sample, a statistical method presented by Pedro Morales Vallejo (2012) was used to determine the appropriate sample size to ensure the representativeness of the university population. This method considered several factors, such as the total size of the population, the desired confidence level and the acceptable margin of error. Through rigorous statistical techniques, it was possible to establish a sufficient and significant sample that provides reliable and representative results of the needs and demands for sustainable products within the university community.

Subsequently, a detailed evaluation of the economic investment and profitability of the proposed utility model will be carried out. This evaluation will focus on aspects such as production costs. Financial analysis will be carried out to determine the financial sustainability of the project and its contribution to the development of the university store, ensuring that the proposed model is economically viable and can be sustained over time.

3. Results/Discussions/Implementation

3.1 Results

Graph 1 shows that for the year 2023, after ordinary waste, the highest rate of generation belongs to usable waste, where approximately 1,622 kilograms per month were disposed of, for a total of 19,475 kilograms of usable waste generated at the Usaquén facilities of Universidad El Bosque.

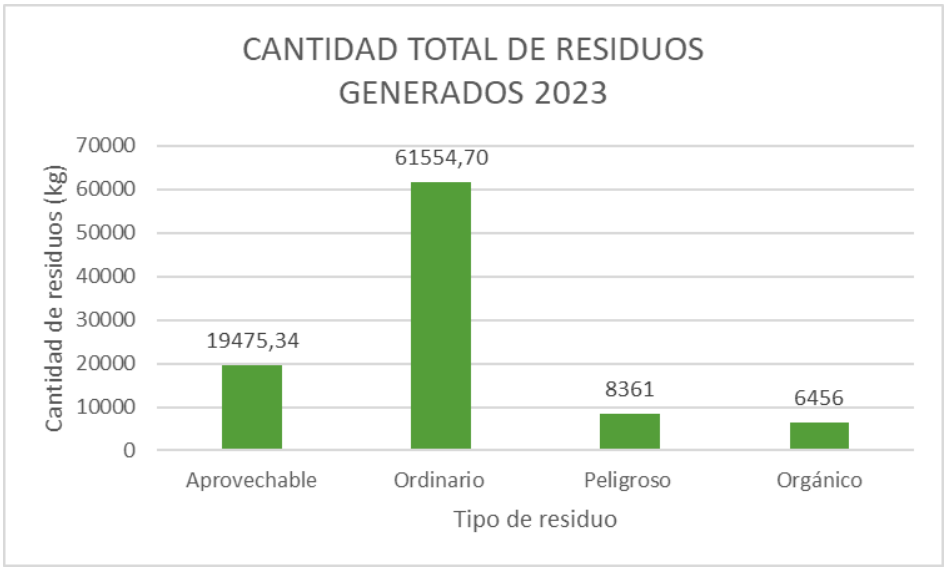

Figure 1. Amount of ordinary, organic, usable and hazardous waste 2023.

Specifically for paper and cardboard materials, 5,097 kilograms of cardboard and 6,790 kilograms of archival paper were generated in 2023, for a total of 11,887 kilograms, as shown in the following graph:

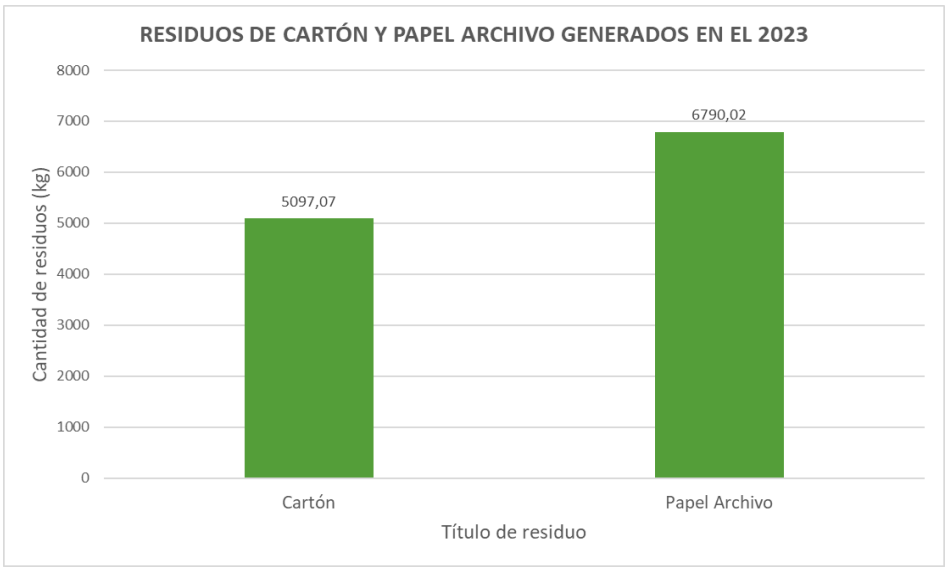

Figure 2. Cardboard and archival paper waste generated in 2023

This figure shows the quantities produced at the Usaquén facilities, which show the feasibility in terms of quantities for the production of goods and products obtained from recycling. Thanks to graph 2, it is determined that the average monthly generation for

cardboard is 424.7 kilograms, while for archival paper it is 565.8 kilograms. It is expected that with the continued development and growth of the institution's population, waste generation and recycling rates will continue to increase considerably.

On the other hand, the study of the sample calculation of the survey implemented to investigate the needs and demands for sustainable products within the university community revealed the adoption of a sound methodological approach. Careful consideration of key variables such as the total size of the university population, the desired confidence level and the acceptable margin of error was observed. This statistical approach provided a sound basis for determining the optimal sample size, thus ensuring the representativeness of the results obtained.

In addition, an appropriate selection of sampling techniques was identified to capture the diversity of the university community. Randomized and stratified methods were applied to ensure that different demographic groups and areas of study were proportionally represented in the sample. This strategy helped to mitigate possible biases and ensured that the survey results were more generalizable and applicable to the entire university population, improving the validity and reliability of the findings.

In this order of ideas, taking into account the context of Universidad El Bosque, where there is a total of approximately 15,585 people, where by 2023, according to the planning area of the institution, 13,201 are students and 2,384 are administrative staff.

The following formula was used to calculate the sample, detailed by Pedro Morales Vallejo in his publication Estadística Aplicada a las Ciencias Sociales (2012).

Sample Size = N * (C * 0,5)21 + (e2 * (N-1)) = 95 (1)

N: Population size

c: Confidence level

e: Margin of error

The quantitative process was carried out to determine the sample, using the aforementioned population size, a margin of error of 10% and a confidence level of 95%. This resulted in a sample size of 95 people.

The completion of 95 surveys to different members of the university represents a significant step in the process of researching the needs and demands for sustainable products within the university community. This sizable sample size allows for a broad and diverse perspective of the opinions and preferences of the different groups and areas of study present at the institution. By encompassing a considerable number of surveys, the reliability and validity of the results obtained is increased, providing a solid basis for informed decision-making on future initiatives related to recycled and sustainable products at the university.

In addition, the selection of 95 surveys allows for capturing a variety of perspectives and experiences within the university community, which enriches the understanding of needs and demands regarding sustainable products. This strategic sampling approach allows for adequate representation of the diversity present at the university, including students, faculty, administrative staff, and other members of the academic community. This ensures that the results accurately reflect current preferences and trends in recycled products, thus facilitating the identification of opportunities and areas for improvement in sustainable product offerings at the institution.

Proceeding with the modeling of the data obtained in the surveys, the following results are obtained:

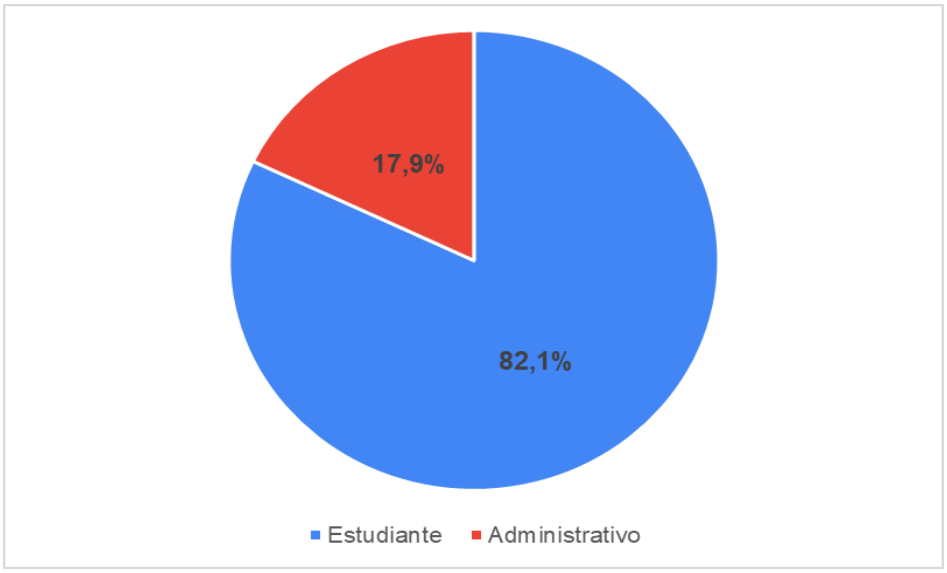

Figure 3. Distribution and classification of respondents

Graph 3 shows that of the 95 people surveyed within the university, 82.1% belong to the student community and the remaining 17.9% belong to the administrative staff of the institution.

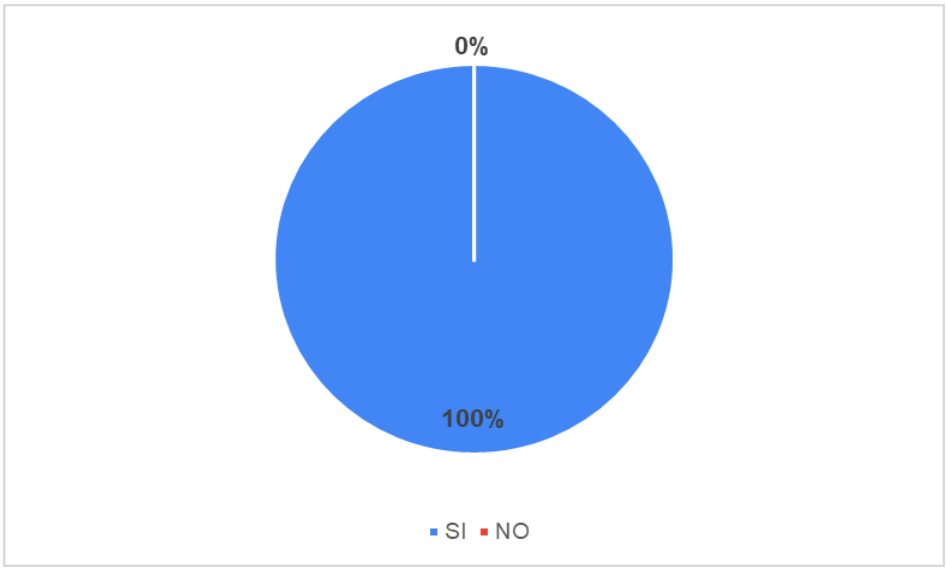

Figure 4. People interested in buying recycled stationery

The results modeled in Graph 4 are an eloquent testimony to the commitment of our university community to sustainability. With an impressive 100% of the sample showing interest in purchasing products and stationery from paper and cardboard recycling and processing, it is clear that there is widespread recognition of the importance of supporting eco-friendly practices. This level of engagement is encouraging and drives us to continue to promote initiatives that foster environmental awareness and responsible consumption within our academic community.

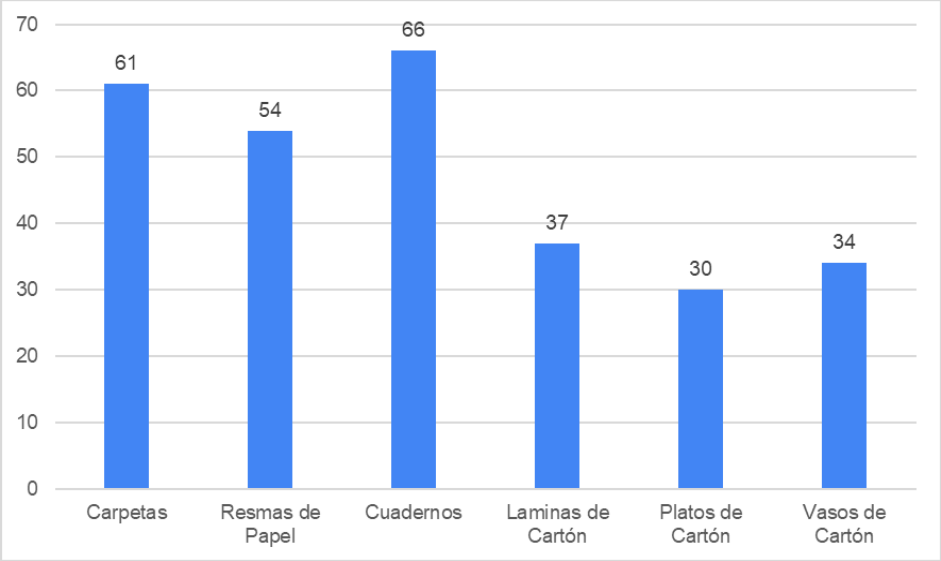

Figure 5. Respondents' interest in each type of stationery item

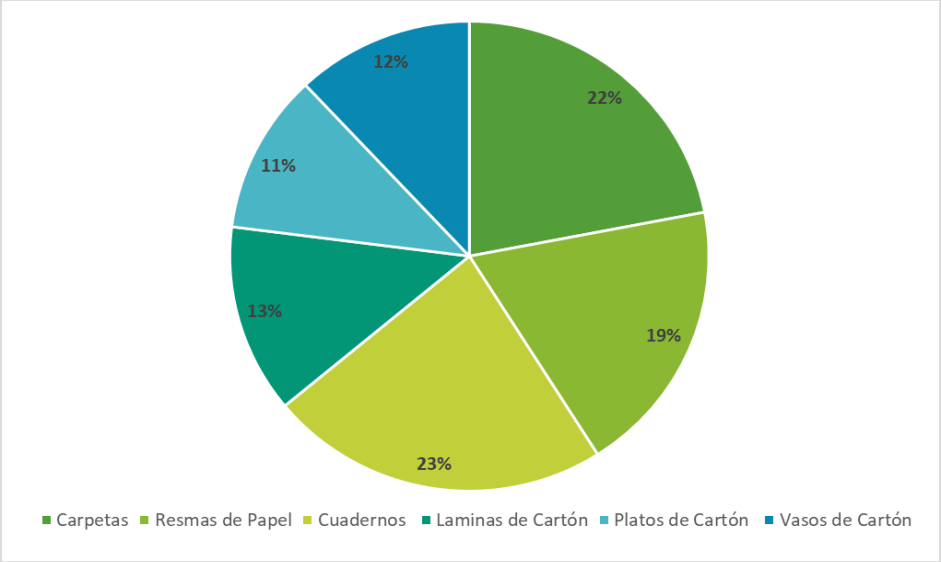

Figure 6. Percentages of interest versus each type of stationery item.

Taking into account the results represented in Graphs 4 and 5, which show the percentage of interest in acquiring each proposed stationery item, it is determined that the item with the greatest interest is notebooks, with 23% of interest, followed by folders and reams of paper, with 22% and 19%, respectively. Additionally, it is evident that the items with the lowest percentage of interest for the respondents are cardboard plates and cups, which represent 11% and 12% of interest, respectively.

In this order of ideas, according to the results obtained from the surveys conducted, it has been determined that the utility model for the recycling of paper and cardboard waste at the university should focus mainly on the production of notebooks, folders and reams of paper. These products have been identified as the most demanded and useful for the university community, which guarantees a greater acceptance and use of the recycled items. In addition, this choice contributes significantly to the reduction of the environmental footprint by promoting the reuse of materials and the conservation of natural resources.

3.2 Utility Model

The proposed utility model is a complete and efficient system designed for the transformation of usable paper and cardboard waste into high quality, environmentally friendly stationery products. This innovative system integrates a series of specialized processes and technologies that allow making the most of recycled materials, thus contributing to the reduction of waste and the promotion of sustainable practices, the cycle of the model components is shown below.

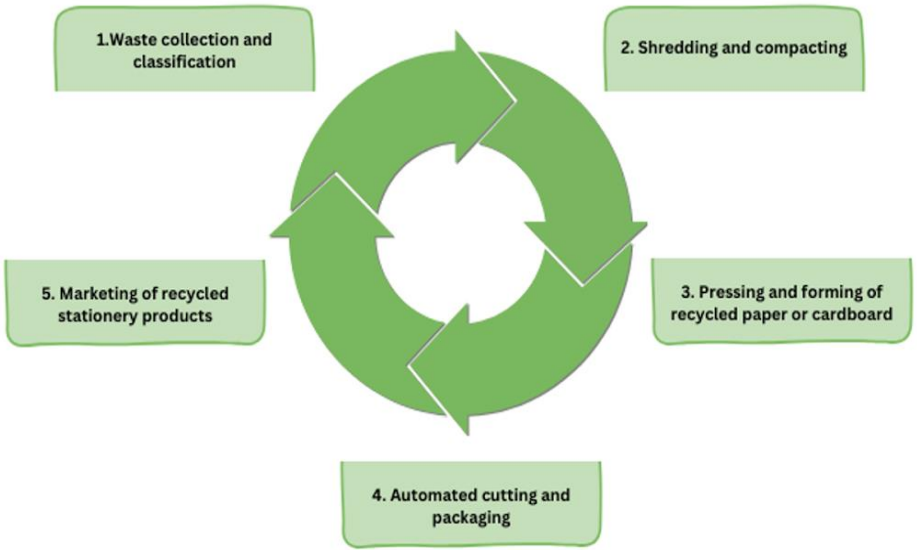

Figure 7. Components of the utility model for the production of recycled stationery

1. **Waste collection and classification:** The process begins with the collection of paper and cardboard waste at different points of the university or community. This waste is then sorted according to its type and degree of contamination, ensuring the quality of the materials destined for processing.
2. **Shredding and compacting:** Once classified, the waste will be transformed into a shredding and compacting machine, where it will be processed to reduce its volume and prepare it for the next step in the process. This stage ensures efficient waste management, optimizing storage and transportation space.
3. **Pressing and forming of recycled paper or cardboard:** The shredded and compacted waste is then transferred to a specialized device that presses and forms it into sheets of high-quality recycled paper or cardboard. This process involves the application of controlled pressure and heat, ensuring the cohesion and strength necessary for the manufacture of durable, good-quality stationery products.
4. **Automated cutting and packaging:** Once the recycled paper sheets are formed, they are automatically fed into a binding and cutting mechanism, where they are bound and cut to the desired specifications for the production of stationery products such as folders, reams of paper and notebooks. This process ensures efficient and accurate manufacturing, minimizing waste and optimizing the use of recycled materials.
5. **Marketing of recycled stationery products:** This component is essential to ensure the dissemination and adoption of these products in the market. It involves developing effective strategies to bring products made from recycled materials to consumers, highlighting their environmental benefits and quality. This involves identifying target markets, establishing a strong brand that highlights sustainability values, expanding the

distribution channel, and conducting education and awareness activities to promote demand for these products. Through effective marketing, the aim is not only to generate income to sustain the model, but also to promote a shift towards more responsible and environmentally friendly consumption practices.

Benefits of the system:

- **Waste reduction:** The system contributes significantly to the reduction of solid waste by taking advantage of recycled materials for the manufacture of useful products such as notebooks.
- **Promoting sustainability:** By transforming usable waste into reusable and environmentally friendly products, environmental sustainability is promoted and dependence on virgin raw materials is reduced.
- **Promotion of the circular economy:** By encouraging innovation and the creation of economic value from waste, the model promotes a more efficient and sustainable production and consumption cycle, fostering the development of the circular economy.
- **Generation of added value:** The production of ecological notebooks from usable waste adds economic and social value to the recycling process, creating employment opportunities and contributing to local development.

The integrated system for the transformation of usable solid waste offers an innovative and sustainable solution for waste management that combines productive efficiency with environmental, social and economic benefits.

3.3 Budget

This budget addresses the implementation of a utility model focused on the transformation of paper and cardboard waste generated at Universidad El Bosque into recycled stationery. This initiative seeks not only to mitigate the environmental impact of the institution, but also to promote the adoption of sustainable practices in the university environment. Through a detailed analysis of the costs associated with the collection, recycling and production of these items, it is intended to establish a financial framework that supports the feasibility and positive impact of this proposal on the university community.

3.4 Discussion

The utility model proposed in this article represents an evolution in university waste management towards a more comprehensive and efficient approach. First, it is essential to understand the concept of a utility model in the legal and technical context. Unlike patents that protect more complex inventions, utility models are designed to address practical and novel, but less technically demanding, improvements. This approach is particularly relevant in academia, where solutions are often found in process optimization and the implementation of innovative practices (Grobman, 1993).

The utility model we present focuses on the management of usable paper and cardboard waste through the circular economy at El Bosque University. Instead of considering waste as a problem, this approach perceives it as a valuable resource that can be reintegrated into the production chain. The basis of this model lies in the identification, classification and efficient channeling of waste generated at the university towards recycling and reuse processes.

The creation and application of a utility model for waste management in a university is of multidimensional importance. First, it responds to the critical need to reduce the ecological footprint of the institution, aligning with the Sustainable Development Goals. Implementing a utility model allows the university to not only comply with environmental

regulations and standards, but also to take a proactive role in building a more sustainable and resilient future.

Table 1. Estimated annual budget

Item	Unit Cost (COP)	Quantity	Total Cost (COP)
Adequacy of the area	10.000.000	1	10.000.000
Storage system (Containers and bins)	800.000	4	3.200.000
Compaction System (Compacting Machine)	16.000.000	1	16.000.000
Shredding system (Shredding machine)	5.000.000	1	5.000.000
Pressing system (Pressing machine)	5.000.000	1	5.000.000
Machinery for the production of stationery	9.000.000	1	9.000.000
Monthly administrative expenses (1 operator)	1.300.000	12	15.600.000
Additional inputs (utilities, chemicals, etc.)	6.500.000	1	6.500.000
Contingency reserve (10% of budget)	6.530.000	1	7.030.000
Total			**77.330.000 COP**

In addition, the development of a utility model drives innovation and applied research within the institution. The interdisciplinary teams involved in the creation and application of the model not only contribute to scientific knowledge, but also generate practical solutions to pressing environmental challenges. The university thus becomes a living laboratory for experimentation and implementation of advanced environmental management technologies and strategies (Vargas, 2022).

In the specific context of El Bosque University, which stands out as an educational institution committed to academic excellence and the integral formation of its students. With a solid trajectory and a vision oriented towards the future, sustainability and social responsibility, the institution manages to integrate these principles in various initiatives and programs, generating a significant impact on society.

Where the institution focuses on processes and strategies to significantly improve waste management procedures, which implies a reduction in waste generation, the implementation of recycling practices and the promotion of the reuse of materials. These actions not only reduce pressure on landfills and reduce environmental pollution, but also contribute to the mitigation of greenhouse gas emissions associated with the degradation of certain wastes.

Integrated waste management and waste recovery have become crucial strategies in the fight against climate change. In a world increasingly affected by the impacts of global warming, it is essential to address waste management in an integrated manner to mitigate

its contribution to climate change and adapt to its effects. Projects that focus on the proper management and utilization of waste not only help reduce greenhouse gas emissions, but also promote sustainability and community resilience to climate challenges.

One of the most important aspects of these projects is their ability to reduce greenhouse gas (GHG) emissions. Waste generates a significant amount of GHGs, especially when it decomposes in landfills or is burned in an uncontrolled manner. Proper waste management, including selective collection, recycling, composting and energy recovery, can drastically reduce these emissions by preventing the release of methane and other harmful gases into the atmosphere. In addition, the use of waste as a renewable resource, such as biogas energy or compost, can contribute to mitigating emissions by replacing fossil fuels with cleaner and renewable sources.

Another relevant aspect is the ability of these projects to promote the circular economy and sustainability. Integrated waste management is based on the principle of reduce, reuse and recycle, which encourages a more responsible approach to consumption and production. By promoting the reuse of materials and resource recovery, these projects help reduce pressure on natural resources and minimize waste generation. Moreover, by creating new employment opportunities in sectors such as recycling and waste recovery, they contribute to sustainable economic development and the creation of a more resilient and diversified economy.

In addition to their environmental and economic benefits, integrated waste management and recovery projects also play an important role in adapting to climate change. As global temperatures rise and extreme weather events intensify, it is crucial to strengthen the resilience of communities to these changes. Proper waste management can help reduce the vulnerability of communities by ensuring food security, water availability and protection against natural disasters. For example, composting organic waste can improve soil fertility and increase its water retention capacity, which is essential for agriculture in areas affected by drought or soil erosion.

Specifically for paper and cardboard materials, 5,097 kilograms of cardboard and 6,790 kilograms of archival paper were generated in 2023, for a total of 11,887 kilograms. Considering that the university has a high generation rate for cardboard and archival paper materials, it is proposed to transform these recycled materials into products such as ecological notebooks, personalized folders, reams of recycled paper or even distinctive stationery items, which would not only contribute to reducing waste, but would also promote environmental awareness among members of the university community. These sustainable products could become tangible symbols of the university's commitment to environmental responsibility, while offering students and staff a conscious and practical option for their daily needs.

Thus, the proposed utility model that transforms usable cardboard and paper waste into stationery for sale at the institution is both important and feasible for several reasons. First, from an environmental perspective, this model contributes significantly to waste reduction and the promotion of sustainable practices. From an economic standpoint, the sale of stationery items made from this waste offers a potential source of revenue for the institution. The marketing of sustainable products in the university store not only satisfies the growing demand for eco-friendly products, but also generates financial resources that can be reinvested in additional social and environmental responsibility initiatives.

In addition, this utility model reflects the institution's commitment to innovation and corporate social responsibility. By adopting sustainable practices and offering products

derived from recycling in the university store, the institution positions itself as a leader in developing creative and viable solutions to environmental challenges. In terms of feasibility, the technology needed to transform cardboard and paper waste into stationery is already available and economically feasible. The facilities and equipment required for production can be efficiently integrated into the existing structure of the university, allowing implementation without major logistical complications.

In summary, the development of this utility model offers a balanced combination of environmental, economic and innovative benefits. It provides a sustainable strategy for waste management, creates financial opportunities and reaffirms the institution's commitment to environmental responsibility, making this approach both important and viable in the university context.

4. Conclusions/Summary/Future Perspectives

In conclusion, it should be mentioned that the utility model aimed at transforming usable cardboard and paper waste into products such as notebooks, folders and reams of ecological paper is not only viable but also sustainable. From the economic point of view, the commercialization of these stationery items generated from recycled materials can constitute a significant source of income for the institution. The current growing demand for sustainable products supports the commercial viability of this proposal, opening opportunities for the consolidation of a sustainable economic model in the university environment.

Additionally, the viability of this model is supported by the availability of technologies and production processes that facilitate the efficient transformation of waste into final products. The logistics infrastructure and facilities required to implement this model can be practically integrated into the existing university environment. In this context, the initiative would not only contribute to effective waste management, but would also reinforce the institution's commitment to sustainability and environmental responsibility, setting a precedent for similar practices in other educational institutions and local businesses.

Furthermore, the application of this utility model, which focuses on the circular economy, is crucial to fostering a culture of environmental responsibility and awareness within the university community and beyond. By converting waste into valuable resources, the university not only minimizes its environmental impact, but also educates students, faculty and administrators about the importance of sustainability. This approach can incentivize other institutions to adopt similar practices, extending the positive impact beyond campus boundaries and serving as an inspiring example to society at large. The implementation of these models can become a distinctive element of institutional identity, promoting an image of innovation and commitment to the future of the planet.

Similarly, it is important to highlight that projects that focus on integrated waste management and utilization play a fundamental role in the fight against climate change and adaptation to its effects. By reducing greenhouse gas emissions, promoting the circular economy and strengthening the resilience of communities, these projects offer a comprehensive and sustainable solution to address one of the greatest challenges of our time. It is crucial that governments, businesses and society as a whole recognize the importance of investing in these projects and working together to implement effective solutions at local, national and global levels.

Finally, promoting the circular economy through this model not only has environmental benefits, but also offers tangible economic advantages. By reducing reliance on virgin raw

materials and lowering the costs associated with waste management, the university can improve its economic efficiency while contributing to the local economy. The creation of recycled stationery products can generate new business and employment opportunities, both inside and outside the university, thus supporting sustainable economic development. This approach demonstrates how educational institutions can lead by example, implementing practical and sustainable solutions that respond to the global challenges intended to meet the Sustainable Development Goals.

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