

## **Sustainable open innovation for ammunition waste management: Proposal for implementation in Brazilian public security institutions**

**Inovação aberta sustentável para gestão de resíduos de munições: Proposta de implementação em instituições de segurança pública brasileiras**

**Innovación abierta sostenible para la gestión de residuos de municiones: Propuesta para su implementación en instituciones de seguridad pública brasileñas**

Received: 02/05/2024 | Revised: 02/14/2024 | Accepted: 02/15/2024 | Published: 02/18/2024

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### **Abstract**

The study describes how looking at collaborative processes with a sustainable bias can effectively contribute, through sustainable open innovation, to opportunities for solving challenges of the same context. Therefore, we present a study proposal to improve the public security arena (reverse logistics of ammunition expended in training), aiming at recycling the generated waste. The research strategy was case study analysis, which is appropriate for investigating real-life events. It was necessary to understand which factors contribute to qualifying the requirements for reverse logistics and sustainable innovation in public security institutions. The specific objective is to link the maturity level of the public security institutions to its goals in reverse logistics, to give greater view to implement it. As a result, we were able to increase the current status of knowledge regarding the sustainable disposal of expended ammunition cases and get a better understanding of the economic gains by selling the brass scraps waste (expended ammunition) as a large expected benefit, collaborating to reduce the customer's costs by enhancing their reverse logistics processes. Also, considering the solutions to complex problems through collaboration, knowledge of purposes, and organizational maturity, point out the relationship between sustainability and innovation.

**Keywords:** Open innovation; Innovation management; Sustainability; Ammunition cartridge; Organizational process; Public security; Reverse logistics.

### **Resumo**

Este estudo descreve como processos colaborativos, com viés sustentável, podem contribuir efetivamente, para resolução de desafios de mesmo contexto, utilizando-se da inovação aberta sustentável. Ademais o estudo possui como norteador propostas de melhorias, no âmbito da segurança pública (logística reversa das munições gastas em treinamentos), visando a reciclagem dos resíduos gerados. Assim, foi necessário compreender quais fatores contribuem para a inovação sustentável nas instituições de segurança pública, bem como qualificar os requisitos de logística reversa. O objetivo específico é vincular o nível de maturidade das instituições de segurança pública aos seus objetivos em logística reversa, para dar maior eficácia à sua implementação. Como resultado, registra-se maior conhecimento sobre o descarte sustentável de estoques de munições utilizadas em treinamento e melhor compreensão dos ganhos econômicos com a venda de resíduos (munições utilizadas) como benefício esperado, colaborando para reduzir os custos, aprimorando os processos para implementação da logística reversa. Além disso, ao considerar soluções para problemas complexos, por meio da colaboração, do conhecimento e da maturidade organizacional, destaca-se a relação entre sustentabilidade e inovação.

**Palavras-chave:** Inovação aberta; Gestão da inovação; Sustentabilidade; Cartucho de munição; Processos organizacionais; Segurança pública; Lógica reversa.

### **Resumen**

Este estudio explora cómo dentro de los procesos colaborativos con parcialidad sostenible se puede aprovechar la innovación abierta sostenible para abordar de manera efectiva los desafíos apremiantes. Proponemos un estudio de caso centrado en el ámbito de la seguridad pública, específicamente la logística inversa de municiones gastadas y su potencial de reciclaje. Nuestro objetivo principal es vincular el nivel de madurez de las instituciones de seguridad

pública con sus objetivos de logística inversa e identificar obstáculos a la implementación. La estrategia de investigación fue el análisis de estudios de casos, que es apropiado para investigar eventos de la vida real. También se definen los criterios de sostenibilidad y responsabilidad, con el apoyo de la literatura sobre logística inversa, innovación abierta y sostenibilidad. A través de este análisis, tenemos la intención de mejorar el conocimiento aumentando la comprensión de la eliminación sostenible de depósito de municiones gastadas; Evaluar las posibles ganancias financieras de la venta de residuo y promover la colaboración en la resolución de problemas que pueden conducir a soluciones innovadoras. El estudio contribuye al conocimiento existente al demostrar la aplicación práctica de la innovación abierta sostenible en el sector de la seguridad pública. Destaca los beneficios económicos y ambientales de una logística inversa eficiente; vincular los niveles de madurez de las instituciones de seguridad pública con sus objetivos de logística inversa revela posibles obstáculos a la implementación.

**Palabras clave:** Innovación abierta; Gestión de la innovación; Sostenibilidad; Cartucho de munición; Procesos organizacionales; Seguridad pública; Logística inversa.

## 1. Introduction

Through open innovation, institutions can and should seek new ideas and technologies inside and outside the organization's boundaries, as introduced by Chesbrough (2003). Since the term open innovation was coined, a proliferation of literature has appeared to provide the theoretical background (Stanko *et al.*, 2017).

A decade ago, Chesbrough and Brunswicker (2013) had already counted big companies in Europe and the United States that used to practice open innovation at 78% and none of them abandoned this practice. Open innovation can be considered a driver of major partnerships between clients, universities, and industry, according to their report.

As a strategic niche, interest in and focus on environmental sustainability has been growing recently, because manufactures have been called to contribute to eliminating the waste and pollution, reducing the use of resources and managing the cycle of life of products. To address these and other sustainability issues, the concept of the Circular Economy has recently gained importance on the agendas of policymakers (Brennan *et al.*, 2015).

In fact, according to literature, more and more, product and process innovation is beginning to show evidence that organizations are starting to become aware of environmental sustainability (De Medeiros *et al.*, 2017), aiming at fostering innovation with sustainability benefits and securing the sustainability of those innovations.

The use of external sources of knowledge, such as customers, consultants and universities, is key to achieving a greater level of innovation, generating product and process innovation. This is from the study by Gomez *et al.* (2016) which is in line with the open innovation literature.

Market and industry examination of environmental issues is not recent. Since 1995, it has been ensured that environmental causes do not make economic results unfeasible (Donaire, 1995, p.50) and some aspects of sustainable culture are correlated with financial success or an outcome of success (Schönborn, 2019). However, the environmental variable in an organization must be implemented through planning and guiding in order to reach strategic results arising from engagement in the environmental cause.

New guidelines, regulations, and laws designed for the execution of government actions and public policies are measures to increase environmental protection and promote competition through green strategies reconciled with industrial performance (which aims at profit). Raw materials originating from mineral stocks are the focus of initiatives and challenges from manufacturers and the government, to deal with the global scarcity of natural resources. The search for iron ore is so relevant for security and defense purposes that it could even be a reason for conflicts between nations (Bell *et al.*, 2013).

The environmental protection standards within the European Union are the result of decades of work in response to a variety of environmental problems (Damacena, 2011). Estimates of these environmental policies in the European Union date back to 1990 and also have progressed and developed to the point of identifying and exploring drivers (Zito *et al.*, 2020).

In recent decades, reverse logistics has attracted the attention of companies and researchers given its importance in consolidating sustainable actions by the government, manufacturers, and consumers. The theory of sustainable open innovation is used in this study, as a theoretical lens for the case study ammunition waste management, as a potential response to the problems of implementing reverse logistics of triggered ammunition in Brazilian police institutions.

The first purpose of this study is to describe how collaborative processes, with a sustainable bias (sustainable open innovation) can effectively contribute as opportunities for solving challenges that have the same context (ammunition case). Secondly, exploring the maturity level of the public security institutions linking to its goals in reverse logistics, to give greater effectiveness to implement it.

From a contextual perspective, the EPI - Environmental Performance Index<sup>1</sup> measures environmental sustainability performance through a methodology that evaluates and classifies the performance of 180 countries. This index helps to guide public policies and government agendas. In the 2022 EPI ranking<sup>2</sup>, Brazil was in 81st position.

The National Solid Waste Policy of Brazil was published in 2010 after the specific European Directive norms for waste management, which date from 2008 (Directive 2008/98/EC<sup>3</sup>) and aimed at treating and developing waste management policies and plans.

Among the objectives of the European Commission for the Environment<sup>4</sup>, responsible standardization on that continent is to encourage innovation and recycling, as well as improvements in waste management, which is in common interest with the present study. Moreover, the United Nations 2020 to 2030 agenda for Sustainable Development presented a challenge to seek Sustainable Development Goals (UNEP, 2020). One of the proposals recommends the production and use of products and services that meet social needs, providing a better quality of life and minimizing the use of natural resources and toxic materials, and reducing the generation of waste and emissions over time, checking the Life cycle of products and services, and avoiding damage to future generations.

According to the 2030 Agenda<sup>5</sup> of the United Nations (2022), there are seventeen Sustainable Development Goals (SDGs) —divided into 169 objectives — that aim to balance economic, social and environmentally sustainable development. The main purpose of this research is linked to SDG 12 – Ensure sustainable consumption and production patterns by the target 12.5 – By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse. It's also about encouraging companies, especially public security institutions, to adopt sustainable practices. That is why this study is a significant step on the road to sustainability to ensure the journey results in gains and also to promote a more prosperous and sustainable Brazil.

Brazilian Public Security is derived from the Federal Constitution into public policies. There are 27 regional forces in Brazil, in the 26 states and the federal district; all of them have three different mission profiles (military, civilian and custodial detention). All in all, there are 86 corporations of public security (Figure 1) working locally or nationally (Yearbook of Public Security, 2022).

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<sup>1</sup> <https://epi.yale.edu/> homepage about environmental performance index and respective practical guidance for countries that aspire to move towards a sustainable future, as help to detect problems, define goals, track trends, understand results and identify best practices in environmental policies.

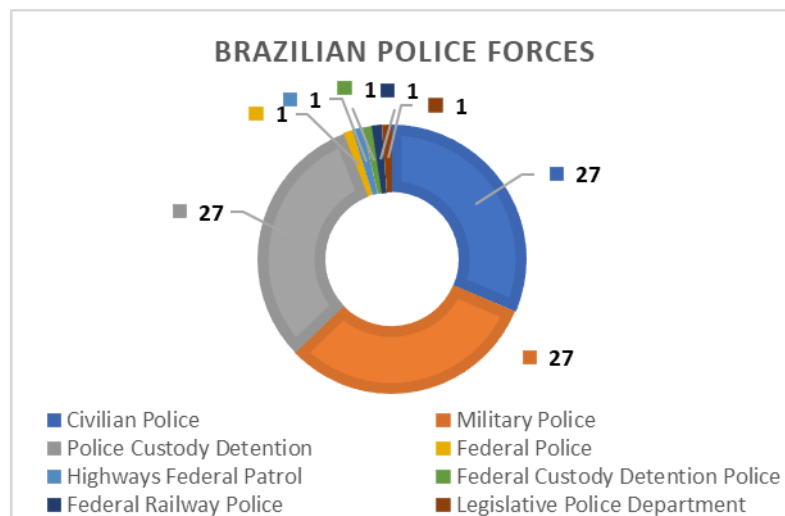
<sup>2</sup> <https://epi.yale.edu/epi-results/2022/component/epi> Result of Environmental Performance Index 2022

<sup>3</sup> Directive 2008/98/EC of European Parliament and the European Union Council on waste, last update: may, 7th, 2018 (available in <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098>)

<sup>4</sup> [https://environment.ec.europa.eu/topics/waste-and-recycling\\_en](https://environment.ec.europa.eu/topics/waste-and-recycling_en) objectives of EU policy to protect the environment.

<sup>5</sup> <https://sdgs.un.org/2030agenda> - Transforming our world : the 2030 Agenda for Sustainable Development

**Figure 1** - Brazilian Police Forces.



Source: Yearbook of Public Security (2022).

Public security, which regularly purchases ammunition for use in police action and for training, is inserted in this context. All police officers receive ammunition for training, aimed at maintaining a consistent professional level of performance within the force.

The objective of this article is to show a link between the level of maturity of public security institutions and their objectives in reverse logistics. The next step will be to introduce the methodological aspects, the literature review followed by the context details of the ammunition case, discussion and maturity level, ending with conclusions, limitations and future research gaps.

## 2. Methodology

Bibliographical research was conducted via the collection and selection of data through the survey of publications relevant to open innovation, sustainability and reverse logistics. As this study is a piece of exploratory research, it aims to “provide an approximation overview” (Gil, 1999, p. 43) of characteristics that influence open innovation processes. The research strategy is to use case study analysis, which is appropriate for investigating real-life events, Yin (2010).

The search was conducted in the Scopus and Scielo databases using *expended small arms cartridge case* and *fired cartridge case*, with filters delimit the last 10 years to ensure more results. Document types weren't selected, so all available types were included. The search resulted in no results for the term *expended small arms cartridge case* and seventy-five results for the term *fired cartridge case*. However, the content of all these results was related to forensic ballistic examinations.

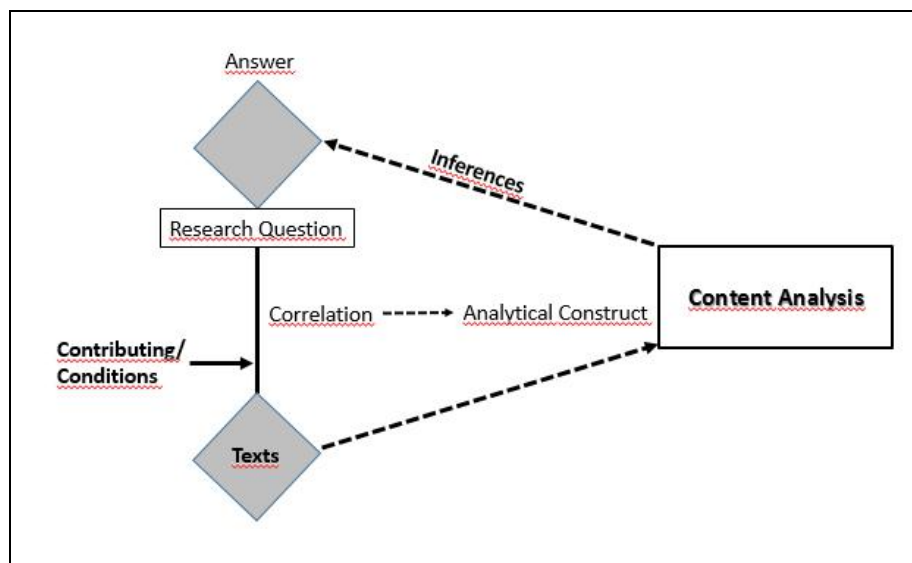
A new search strategy was applied in the Scopus database, involving the terms *used ammunition; control used ammunition; shells empty spent case ammunition; cartridge expended; and expended small arms cartridge cases*. No results were obtained. Due to the scarcity of results that met the research objectives, international journals that deal with the theme of logistical management were also consulted, as well as the Brazilian Digital Library of Theses and Dissertations of CAPES and Google Scholar.

To ensure relevance and avoid redundancy, we selectively included scientific review articles, bibliometric research, or systematic reviews that explore themes like reverse logistics, sustainability, and open innovation in the public sector. These selected references then served as both a guide and a comparison point for evaluating articles relevant to our specific research topic.

This study can be classified as a narrative review that is obtained by examining articles on certain topics to develop the synthesis of knowledge, the incorporation of applicability in concrete cases, as well as to elucidate the results practically and analytically on a proposed topic (Souza et al., 2010).

Based on the analysis of the Carlsberg case (Bogers et al., 2020) and Chesbrough et al. (2018), a collection of information deemed relevant to guidelines and relational analysis that could be applied to the context of the expended ammunition case, restricted to the context of sustainable open innovation took place. By the comparison of the actors and projection of the results obtained in the theoretical research (Figure 2) it was possible to realize what can be obtained in the reverse logistics process of the ammunition used by the police.

**Figure 2** - Content analysis and academic research.



Source: Adapted by the author from Krippendorff (2004, p. 30).

This is an exploratory study focused on a real situation previously described that predicted open collaboration of different actors, innovation and multidisciplinary.

As this paper is a part of a broader ongoing study, there is a proposal on how to determine the maturity level of the institution. This proposal is an attempt to encourage the practice of reverse logistics in public safety institutions that can be guided in specific areas (Reverse Logistics Awareness, Waste Management and Ammunition Management) to address the lack of knowledge and close the gaps in sustainably managing the waste. Our questions can be found in APPENDIX A. The questionnaire will be applied to police members of public security, working in the logistics area, and dealing with ammunition management.

It is important to present the actors identified as potential collaborators in the expended ammunition case, attributing, in the author's view, to each of them the interest in being a participant and collaborator.

In this field of public security, as in other government areas, the greatest currency is given to studies that identify and address a significant gap within the literature; investigate something overlooked, under-appreciated, or potentially misunderstood in current understanding of a given phenomenon researching about something (Nowell & Albrecht, 2018).

Regarding the requirement of removing the marking on the case, the basic rule is to remove the traceability marking through an environmentally friendly method. Another relevant aspect is that if the manufacturer sees the potential for greater economic, environmental, and operational viability gains in the recycling of expended cartridges, they would obviously act as partners in the construction of a reverse logistics process for expended ammunition, avoiding overexploitation of natural

resources.

This is a case study with descriptive characteristics and included bibliographic research information and the context of cartridge case ammunition expended by public security institutions and challenges about depleting metal resources. The methodology is consistent with the objective of the study, which is to describe how collaborative processes, with a sustainable bias (sustainable open innovation) can effectively contribute as opportunities for solving challenges that have the same context (ammunition case) as the emerging phenomenon of open innovation in a real context. At the same time, the study also aims to be explanatory and tries to reveal the processes of sustainable open innovation and its benefits.

### 3. Sustainability & Innovation: Contemporary Implications

The National Solid Waste Policy, established by Law No. 12,305, of August 2, 2010, emphasizes the shared responsibility for the life cycle of products and reverse logistics. Actions to reduce the volume of generated waste and the impacts on the environment are provided for in the life cycle of each product. Ammunition is included here, from its manufacture, commercialization, consumption, and waste (cases) disposal.

Through reverse logistics, procedures and means are defined to enable the collection and return of waste to the manufacturer for use or disposal that is favorable for the environment. The product life cycle is a series of steps that involve product development, obtaining raw materials and inputs, the production process, consumption, and final disposal, as defined by Law No.12,305/2010, which institutes the National Solid Waste Policy (PNRS).

The same Law establishes shared responsibility for the life cycle of products; it must be implemented individually and in a chain, covering manufacturers, importers, distributors and traders, consumers, and holders of public urban cleaning and solid waste management services. The single paragraph of Art. 30 of the Law establishing the PNRS translates shared responsibility as:

Single paragraph. The shared responsibility for the life cycle of products aims to:

- I - reconcile interests between economic and social agents and business and market management processes with those of environmental management, developing sustainable strategies;
- II - promote the use of solid waste, directing it to its production chain or to other production chains;
- III - reduce the generation of solid waste, material waste, pollution, and environmental damage;
- IV - encourage the use of inputs that are less aggressive to the environment and more **sustainable**;
- V - encourage market development, production and consumption of products derived from recycled and recyclable materials;
- VI - enable productive activities to reach efficiency and **sustainability**;
- VII - encourage **good social environmental responsibility practices** (BRASIL, 2010, emphasis added).

The PNRS law also defines the concept of reverse logistics as an instrument of economic and social development, constituted by a set of actions, procedures and means designed to enable the collection and return of solid waste to the business sector, for reuse, in its cycle or in production cycles, or other environmentally appropriate final destination.

Couto and Lange (2017) emphasize that the new PNRS concepts brought the shared responsibility for the product's life cycle, with individualized and chained attributions among all links in the production system, as well as with responsibilities for the consumer and the public sector.

According to the United Nations Environment Program's Life Cycle Management: Business Guide to Sustainability, the definition of sustainable production is not a one-size-fits-all concept, it should be tailored based on the life cycle profile of the specific product, business strategy, skills, and organizational culture. Furthermore, it can be applied to both goods and services (UNEP, 2007).

Innovatively, in the same United Nations program, based on the United Nations life cycle, managing based on the life

cycle allows the organization to seek ways to reduce the environmental and socioeconomic impacts of the product throughout its life cycle. Therefore, the life cycle management model aims to address the sustainability of the product's operational performance.

Sustainable open innovation:

[...] is a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model, thus contributing to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Chesbrough *et al.*, 2014, p. 1507).

For the authors Boger *et al.* (2020), the participation of multiple actors helps to identify viable paths for public authorities in their attempt to achieve sustainability goals, and this means that public actors can support the resulting strategies with greater confidence.

Sustainability has become an imperative responsibility for manufacturing industry to survive nowadays. On the other hand, the manufacturing industry has to seek innovative products and processes, contributing to the realization of a circular economy and achieving economic benefits at the same time (Seelen-Luna *et al.*, 2021).

Disregarding reverse logistics for the ammunition acquired by public security agencies means running an environmental risk, as the need to restrain the disposal of tons of brass-plated steel along with waste into the environment has already been identified. Incidentally, attention is required because the expended cartridges are considered hazardous waste due to their flammability, corrosivity, reactivity, toxicity, pathogenicity, carcinogenicity, teratogenicity, and mutagenicity characteristics, with risk to public health or environmental quality.

Additionally, according to the PNRS Law, there is an environmentally appropriate final destination, which is a waste destination that includes reuse, recycling, composting, recovery, and energy use.

According to Leite (2009), the definition of reverse logistics is more extensive:

Reverse Logistics is responsible for managing the planning, implementation, and control activities of materials and information obtained after their sale or consumption, which can return to the business cycle where they were generated, or can be forwarded to other production cycles, for revaluation and reintegration into the market, in different ways or uses, through reverse distribution channels. (Leite, 2009, p. 12).

The disposal of solid waste was already a worldwide concern and, in 1981, Brazil instituted the National Environmental Policy, regulated by Law No. 6,938/81 (BRASIL, 1981) as the starting point of government concern with environmental degradation, later including waste.

The sustainability philosophy must become part of the decision-making process when analyzing the product's life cycle, when choosing the product developer and when choosing the consumer. Table 1 presents six key environmental philosophies championed by United Nations Environment Programme (2007), offering a framework for understanding sustainable development.

**Table 1** – 6R philosophy – of Sustainability.

<p><b>RE-think</b> the product and its functions. For example, the product may be used more efficiently.</p>	<p><b>RE-use</b> Design the product for disassembly so parts can be reused.</p>	<p><b>RE-pair.</b> Make the product easy to repair e.g., via modules that can easily be changed.</p>
<p><b>RE-duce</b> energy, material consumption and socioeconomic impacts throughout a product's life cycle.</p>	<p><b>RE-place</b> harmful substances with safer alternatives.</p>	<p><b>RE-cycle</b> Select <b>materials that can be recycled.</b></p>

Source: UNEP Life Cycle Management (2007, p.13).

Barbieri *et al.* (2010) state that the assessment of social environmental consequences should be part of the innovation processes and not just the economic assessment. They also observe an aspect that is generally neglected in sustainable organization models, when it comes to consumption, promoting demand for new products that save environmental resources, are not unhealthy, are recyclable, and emit little pollutants.

According to Bell *et al.* (2013), supply chain management activities focusing on resource recovery can directly reduce the extraction of non-renewable resources (e.g., metals, minerals, oil) and can indirectly reduce degradation of the underlying resource base of renewable resources. If the forces of consumption, competition, and degradation push natural resources towards higher levels of scarcity that cannot be balanced by replacement and discovery, resource recovery will have to play a more significant role in mitigating shortages.

According to Gonçalves-Dias *et al.* (2012), the importance and relevance of implementing sustainability management in a supply chain is justified by the actions of manufacturers, government, and society, respectively, (1) in decision-making for product development and management of reverse flows; (2) in the elaboration of public policies; (3) directing societal awareness programs regarding consumption and disposal habits, as well as attention to raw material sources.

#### 4. Expended Ammunition Case

The object of analysis of this study is ammunition, one of the inputs of public security institutions, which have powers provided for by law, such as investigating criminal offenses, preventing and repressing crimes, and exercising police functions, among others. To carry out the institutional mission, it is necessary to equip the police with equipment, weapons, and ammunition to fulfill, in a way that is standardized and compatible with the danger faced, carrying out their police duties.

Thus, the ammunition purchase process is a routine task for public security institutions. However, as it is a product controlled by the Army Command due to its destructive power, causing damage to people and property, the purchase is carried out in a controlled and systematic way by the Army, even if it is for police use.

The fact that deserves attention is the protection and control of the marking that is registered on the base of each ammunition case, linking the ammunition to its buyer from the sale moment (for traceability purposes, provided for in applicable legislation). Hence, if the cartridge or shell casing is refilled, it could be used for a different purpose, including the commission of crimes. Figure 3 shows plenty's of expended ammunition collected after training exercise.



**Figure 3** - Expended ammunition cases.



Source: Author's personal archive (2022).

It is also important to observe that ammunition has components that pollute the environment. According to Guedes (2009) open areas intended for training (soil and water) and their surroundings are impacted by heavy metals such as lead, cadmium, and copper. Sorvari (2018) also recognizes risks to both terrestrial and aquatic ecosystems present at a shooting range. Even if the soil generally receives the primary contaminant load, there is also a risk to groundwater and surface water pollution due to contaminant transport from soil by runoff.

We cannot overlook factors such as decontamination, an obligation provided for in Law No. 6,938, of August 31, 1981, which allows the National Environmental Policy, to impose the obligation, on polluters and degraders, to repair the damage to the environment and/or indemnify other parties (Brasil, 1981).

Decisions in logistics are fed by data that, being available in quality and quantity, provide decision makers with the best analysis; in short, support of information available to logistic managers at all levels makes the best decisions possible (National Research Council, 2014).

Complementarily, reverse logistics emerged a few decades ago to reverse the flow, from consumer to origin. (Rogers; Tibben-Lembke, 2001). The benefits of reverse logistics are being discussed and disseminated worldwide, including the collection steps and the effective procedure for recycling, reusing, reconditioning, or even waste disposal to protect the environment. An important aspect of reverse logistics processes is the role of the customer, regarding how consumers can obtain financial return through their outbound returns process (Hazen, 2012).

The recyclability of materials depends on their composition, the elements used in their production, and the difficulty of returning them to the manufacturer or to a distribution center after consumption; all of which result in a complex reverse flow that has not yet been a priority for all customers or manufactures.

Following this brief contextualization, an investigation of how open innovation can create a collaboration network, open to voluntary participants who can and wish to collaborate for a solution. Among the motives for this research, are the following:

- Open innovation can help build a model for reverse ammunition logistics, considering sustainability criteria, existing regulations, and environmental responsibility;
- There are no records of the operational and economic viability of destroying the traceability code markings (expended cartridges, empty cases) before sending it for recycling;

- The government can establish public policies to ensure that all public security institutions can adopt reverse ammunition logistics.

According to Rezaei and Behnamian (2022), cooperation in supply networks is dealt with as mutual support in relationships. The benefits are of common interest in the present case (manufacturer and consumer), related to the reverse logistics project of expended small arms cartridge cases.

## 5. Discussion

If the current world conditions of extraction and pollution remain the same, the scarcity of raw materials is expected to increase over time in the industrial sector, and waste disposal will also be affected over time, but in a direction contrary to scarcity. The same context is expected in different fields of suppliers, including ammunition's raw materials.

As consumption, competition, and degradation of the natural resource base result in higher levels of scarcity, they need to be balanced by replacement, discovery, recovery, and cultivation, playing a more significant role in mitigating scarcity as allied forces (Bell et.al, 2013), in conclusion there is a lot of to implement to prevent scarcity.

The return flow between consumers, suppliers and interested recycling firms brings gains in effective environmental practices and the government from a customer's point of view can and is already requiring green purchasing by public agencies. All of these are sources of information for achieving sustainable innovation outcomes. It involves planning and long-term impacts. Per the research by Adams et al. (2016), sustainable innovation is long-term linkages, emphasizing how to develop and exploit external linkages in pursuit of sustainability objectives.

According to the Yearbook of Public Security (2022, p. 308), the Brazilian government's investment in public security forces especially for law enforcement functions (Union) was reduced by 27 % between 2020 and 2021. The effort to raise investments in public security is a societal hope because there is a primary need prevention and protection from criminal acts, and safeguarding public order. Of course, the gains from reverse logistics implemented can save financial resources and increase investment in police forces and it is a virtuous cycle. The ammunition consumer, in this case, police institutions, can and should take on the role of coordinating a study project aimed at systematizing waste management to add collaborators (actors) so that each one takes on the part that is aligned with its strategic objectives.

Considering the coordination of an innovative study project, this research can provide knowledge for more than one institution, taking into account that the problem of waste management happens in around 86 police Brazilian forces. This is one of the contributions of this paper related to previous research.

### 5.1 Influence and justification

After the literature review presented in section 2 and throughout this paper, it is fair that the present study addresses complementary perspectives on open innovation in the context of collaboration between actors for waste management (ammunition) in public security institutions.

Del Carpio Gallegos and Seclen-Luna (2022) conclude in their study regarding the approach of open innovation, especially the practice of interacting with different external sources of knowledge to improve their technological innovation capacity, they improve their capacity for technological innovation.

From the concrete case of Carlsberg Brewery's green fiber bottles, came the conclusion that the concept of open innovation is very useful to effectively describe and coordinate activities related to sustainability objectives, which is why the development of sustainable open innovation is encouraged. As well as identifying the objectives of the interested parties and the organization, to ensure that the results are consistent with the desired objectives.

According to Boger et al., (2020), public agencies can scale initiatives to ensure that they reach further than if they were left only to private actors. These are examples of initiatives: Development of strategies and business models aligned with the concept of sustainable open innovation.

On the other hand, it is important to bring up the literature that says that the role of the customer has been noted as being an important aspect of reverse logistics processes, yet it has received little attention in the literature (Hazen et al., 2012). The same authors, in the sequence, add that investigation regarding how customers can reduce costs by enhancing their reverse logistics processes may be a fruitful area for future research (Hazen et al., 2015).

Internationally, the Eimers (2019) study includes related procedure instructions in the form of the Department of Defense Procedures Manual (DoD, 2019) for the subject of disposal of military ammunition cartridges used in the United States, which systematizes the waste management for the Department of Defense. This is an illustration of the reverse logistics of cartridge cases used in training delivered by military institutions. In the same study, as proof of how profitable it is to turn to the recycling market in the USA (Air Force /Department of Defense), they expect scrap brass waste (at market price) estimated at over \$1 million a year.

The implementation of ammunition reverse logistics does not guarantee that all 86 Brazilians Police Forces are ready for this innovation, the maturity level can be considered a key to indicating from where to start the process, what are the first steps for each institution according to their understanding and awareness about reverse logistics.

For a reverse logistics network to be possible, capabilities to implement it in public security institutions are necessary, and it is so related to organizational maturity, that it allows the identification of consumer requirements, and maturity in the innovation process (D'Alvino & Hidalgo, 2012). Finding the maturity level of police institutions can be a way to organize a solution to a problem, improving the innovation process.

## **5.2 Maturity level**

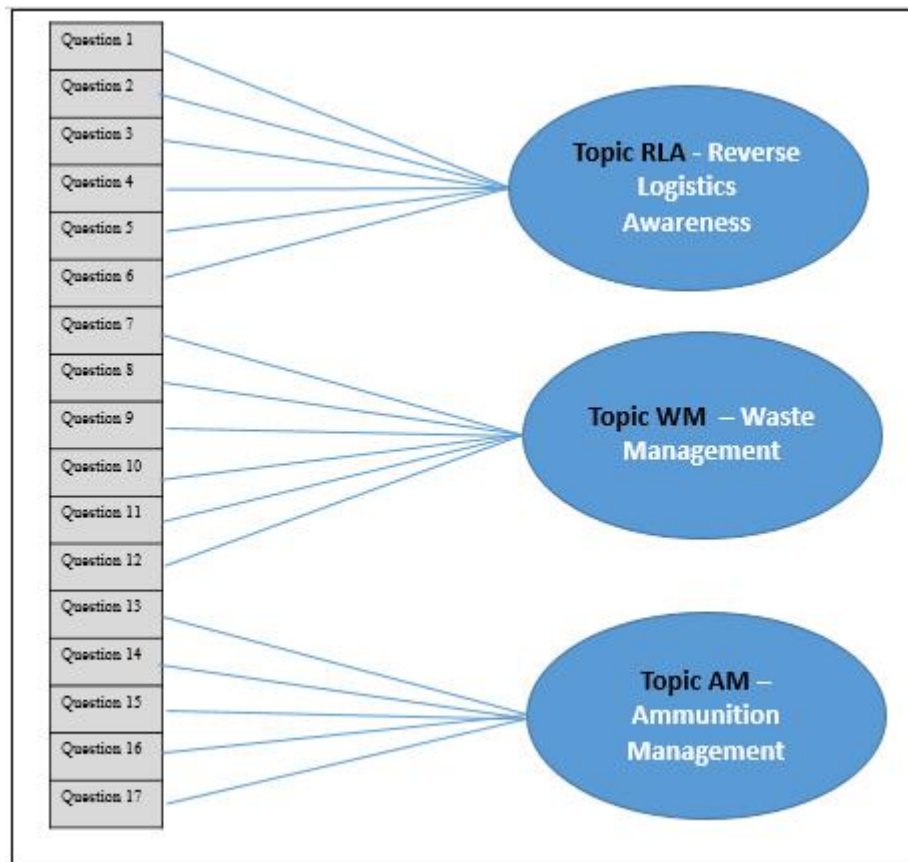
The maturity level of police institutions regarding awareness of reverse logistics, ammunition management, and waste management can and should be evaluated to direct efforts in pursuit of sustainable management. An assessment and evaluation of the organization's maturity can be carried out to help define the directives to promote sustainable innovation after obtaining (in the public security context) the reverse logistics awareness level applied to ammunition and waste management.

To encourage research, a questionnaire will be answered by police institutions that addresses functional aspects directly, to obtain relevant and useful information. Henceforth the names Reverse Logistics Awareness (RLA), Waste Management (WM) and Ammunition Management (AM) level are going to be used.

The classification of RLA, WM, and AM themes will take place on three levels. Each level is determined according to the expected characteristics, defined before the application of the interviews. The criteria were defined according to theoretical sensitivity, by analogy with the process maturity criteria. The maturity model (BPMM - Business Process Maturity Model) can be an effective reference for process improvement initiatives (Tarhan, Tureken; Reijers, 2016).

Another important aspect is the distribution of questions by thematic areas: RLA, WM, and AM. Each question is allocated to a certain theme according to the characteristics defined before the application of the interviews. Figure 4 presents the distribution of questions by theme:

**Figure 4** – Research questions, by thematic área.



Source: Authors (2023).

Some of Rosemann and De Bruin's (2012) maturity criteria explain that maturity reflected in the level of knowledge and skills is becoming requirement to ally strategic objectives and cultural change. It was used as an inspiration and adapted to define the criteria for evaluating the levels for RLA, WM, and AM as a diagnostic tool for innovation purposes.

For classification purposes, some characteristics or requirements of the levels defined for the survey to be applied:

**Level 1 – Initial state** - Does not have any initiative or has very uncoordinated and unstructured initiatives. Demonstrates a combination of the following characteristics: Various approaches or methodologies, tools, and techniques; some dependence on external expertise; high level of manual intervention and corrections.

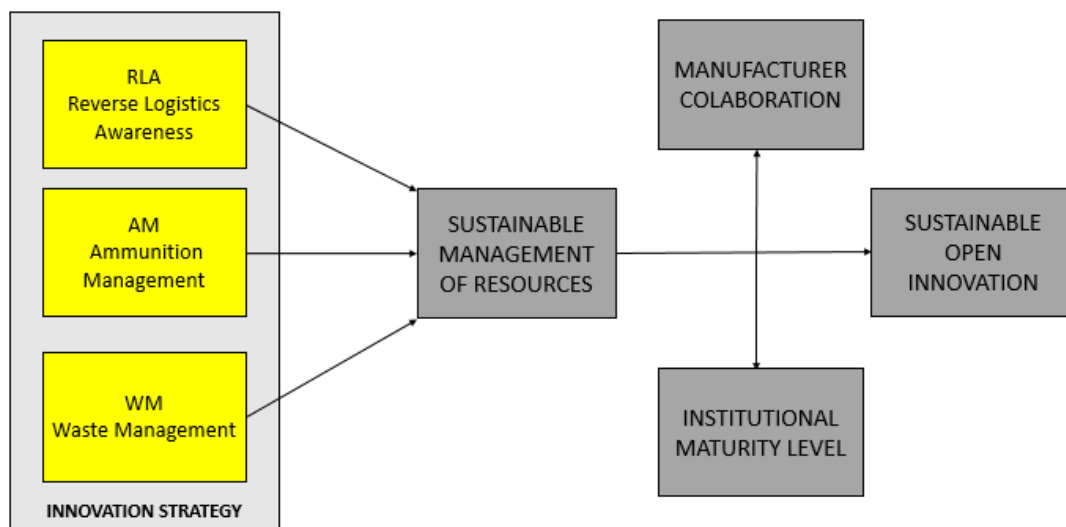
**Level 2 – Ongoing stage** - Demonstrates progress against process experiences. It combines the following aspects: Processes documented for the first time; recognition of the process management importance; growing involvement of leaders and senior management; focus on managing the first stages of the process; and less reliance on external expertise.

**Level 3 – Organization maturity installed stage** - Uses the benefits of processes in Business Process Maturity (BPM) in the organization. Responsibility for maintaining defined standards; using methods and technologies for process control; formalized and designated positions for management; accepted methods and technologies; minimal dependence on external expertise. Established interaction between customers, suppliers, distributors, and other stakeholders.

The maturity level of the score obtained by each institution participating in the research will be established through a classification according to the averages obtained in each level. Each question (in APPENDIX A) is associated with the maturity model and is scored between one and three points.

The evaluation of the results will compose an innovation strategy that involves the police institutions to obtain an indication of the interviewed institution's maturity regarding the implementation of the ammunition reverse logistics. Relative to the previous literature, the framework (Figure 5) shows the strategies around innovative waste management.

**Figure 5** - Open innovation strategies for waste management framework.



Framework Strategies for Sustainable Open Innovation

Source: Authors (2023).

As for the choice, this study is aimed at the improvement of the Brazilian public security area. It aims to increase the status of knowledge regarding the sustainable disposal of expended ammunition casings. Therefore, it seeks to fill this gap (theoretical contributions) by directing its focus and activities to waste management (by public security, in Brazil).

## 6. Conclusion

### Theoretical implications

From the case study of the German company Carlsberg and its experiences, we saw the need for approximation between institutions in favor of sustainable contracting. This belief must also permeate the purchase planning in both public and private institutions, considering the potential influence of reverse logistics. This shows us that the ammunition manufacturing industry and universities can contribute as a partner, specifically to guide technology to destroy/remove the traceability mark in the reverse logistics process, integrating the innovation process.

As a result of the changes in customer demands for the manufacturer, regulations and pro-environmental policies, a swift change is expected in the strategies for processing the expended ammunition environmentally.

A theoretical contribution and general benefit are aimed for, and as a result, enhancing the literature related to the application of the sustainable open innovation approach by proposing strategies for dealing with waste ammunition management, as Obradovic *et al.* (2021) collected in their study about the review and research agenda of open innovation.

The ammunition case has the same sustainable purpose and according to Bogers *et al.* (2020), has advantages like profit being a consequence of the steps taken, business knowledge, trials and errors. Apart from the steps taken, the business knowledge, and the uncertainties experienced, everyone involved received the benefit of being pioneers in sustainable open innovation and being strategically guided by the purpose of sustainability and its potential.

#### Practical implications

Regarding Brazil's case, the treatment of environmental waste management does not have a parameter of equality with Europe, due to facing a recent normative inclusion. In the context of this research, there is a lack of resources to develop the strategies of innovation and there is no systematized ammunition waste management.

The economic gains by selling the (expended ammunition) scrap brass waste has to be considered as a large expected benefit, collaborating to reduce the customer's costs by enhancing their reverse logistics processes. In Brazil's case, it can raise the public security budget, and be seen as a result even for economic dilemmas in developing countries.

#### Future remarks

Considering the governmental guidelines of public policies, the proposals for innovation are very applicable in terms of logistics transformation. From an assertive sustainability vision that is characteristic of consumption reverse logistics, this research seeks to capture strategies to implement and develop sustainability with the collaboration of the involved actors.

In this context, other future lines of research should give more focus to issues related to the implementation of reverse logistics (of expended ammunition) in public security institutions, especially considering obtaining the status of maturity level (seen as confronting and dealing with a limitation), evaluating the possibility of commitment in a sustainable way of each institution.

It is also important that manufacturers can implement their return flow according to the customer's requirements. Moreover, this subject should be seen widely as part of public policies, because the problem exposed is a reality for every single police force (military or not) involving training ammunition and sustainability and it represents tons of waste every year.

Further research could offer critical insights into two areas. First, it can shed light on the complexities and uncertainties involved in recycling these materials within the secondary market. Second, it can contribute to the advancement of sustainable innovation by producing new knowledge. Furthermore, by evaluating the economic gains associated with successful recycling, this research can expand the current conversation, highlighting the potential financial benefits. Additionally, exploring the specific human resource capabilities and skills needed to mitigate the risks involved in this process can equip stakeholders with the necessary knowledge to manage potential challenges effectively.

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