

Management of End-of-Life Tires: Validation of the Questionnaire for the Ecuadorian Land Force

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SUMMARY

The study is part of the research project entitled "Management of end-of-life tires (NFU) of the Land Force in the framework of Social Responsibility" and focused on the methodological validation of an instrument designed to evaluate the management of end-of-life tires in the Ecuadorian Land Force. This instrument, developed under a mixed approach and with the participation of logistics and sustainability experts from different countries, was subjected to an exploratory factor analysis and a Promax rotation was applied. The results showed that the questionnaire has a clear and adequate structure, explaining 79.323% of the total variance in six key components related to logistics supervision, environmental regulations, classification, storage, final disposal, and recycling of NFUs. Cronbach's alpha coefficient greater than 0.85 in all dimensions confirmed the internal reliability of the instrument, supporting its use for future research and sustainable practices in military logistics management.

KEYWORDS: Logistics, recycling, social responsibility, methodological validation.

1 Introduction

Logistics management in military institutions, such as the Ecuadorian Land Forces, faces considerable challenges related to operational efficiency and sustainability. In a global context where organizational social responsibility (OHR) is becoming increasingly relevant, the incorporation of sustainable and responsible practices within military logistics is imperative. This need is particularly evident in the management of end-of-life tires (ELT), a key component within the logistics operation that can generate significant environmental impacts if not properly managed (Tipán, 2020).

The recycling and final disposal of NFUs has become a priority for both the civilian and military sectors, especially in Ecuador, where environmental regulations require a structured and systematic approach to waste management. In addition, for optimal waste and waste management, it is important to carry out the CSR diagnosis from the perspective of stakeholders (Armijos et al., 2024). In this context, the Ecuadorian Land Force seeks to integrate a sustainable management model that promotes organizational social responsibility, aligned with international standards and local environmental regulations.

The objective of this article is to carry out a methodological validation of the survey instrument designed to evaluate logistics management practices in the logistics units of the Ecuadorian Land Force. This instrument is part of a larger study on the implementation of organizational social responsibility in the recycling of end-of-life tires. The validation of the instrument was carried out through a rigorous review and evaluation process by logistics and sustainability experts from Spain, Argentina, Colombia, Mexico, Ecuador and Peru. Using expert validation, a consensus was reached on the relevance and clarity of the questionnaire items, ensuring their relevance and effectiveness in assessing key aspects such as sustainability, regulatory compliance, and transparency.

This article describes in detail the methodological process used for the validation of this instrument, ensuring that the questions include fundamental aspects of social responsibility, ensuring that it is coherent, accurate and appropriate for the evaluation of sustainable logistics practices in the Ecuadorian military context (Ecuadorian Land Force).

In this regard, the methodological validation of a research instrument is essential to ensure the reliability and validity of the data collected and, therefore, the quality of the results obtained in a study (Galarza et al., 2024). This process involves evaluating whether the instrument measures what it intends to measure (validity) and whether it does so consistently (reliability). The absence of adequate validation can lead to erroneous interpretations and conclusions that do not accurately represent the phenomenon studied. The validity of an instrument refers to its ability to measure the specific construct to be investigated. There are several types of validity, among which the following stand out:

- **Content validity:** Assesses whether the items in the instrument adequately cover all dimensions of the construct (Cronbach & Meehl, 1955). This validation is usually carried out by experts in the area, who determine if the content of the instrument fully represents the phenomenon of interest.
- **Construct validity:** Corroborates whether the instrument measures the theoretical concept to which it is associated (Messick, 1989). This is done through factor analysis and correlation studies with other related variables.
- **Criterion Validity:** Measures the ability of the instrument to predict or correlate with other established benchmarks. This validation is essential in studies that look for causal or predictive relationships.

Additionally, the reliability of an instrument refers to its internal consistency and stability over time (Nunnally & Bernstein, 1994). If an instrument is reliable, it should produce the same results in similar situations or when the measurement is repeated. Internal consistency is usually assessed using Cronbach's alpha coefficient, while temporal stability can be measured using retest tests.

- **Internal consistency:** Evaluates the coherence of the items with each other. An instrument with high internal consistency suggests that all items measure the same dimension or construct.
- **Temporal stability:** Measures whether the results remain constant over time, which is key for longitudinal or repetitive studies.

An unvalidated instrument can introduce bias into the results and affect the interpretability of the findings. The lack of validity and reliability implies that the instrument may be measuring factors outside the construct of interest, which compromises the internal and external validity of the study. By methodologically validating an instrument, researchers reduce the risks of bias and increase confidence in the representativeness of the data (Carmines & Zeller, 1979).

Therefore, this work is structured in several sections. First, the introduction justifies the importance of the research and presents the main objectives of the study. Next, the methodology describes the validation process of the measurement instrument used, highlighting the procedures used to ensure its reliability and relevance. In the third section, the results obtained from the validation of the questionnaire are presented, as well as a detailed presentation of the instrument. Finally, the article concludes with a reflection on the conclusions obtained and offers recommendations for future lines of research.

2 Methodology

This study uses a mixed approach for the methodological validation of the survey instrument designed to evaluate logistics management practices in the logistics units of the Ecuadorian Land Force, with a focus on organizational social responsibility (OHR). From a comprehensive literature review on environmental management and CSR, a model was developed that includes several key dimensions. The validation of the instrument was carried out using the expert validation method, with the participation of experts from Spain, Argentina, Colombia, Mexico, Ecuador and Peru, then Cronbach's alpha coefficient was applied.

2.1 Selection of the Research Model

For the development of the measurement instrument, an extensive bibliographic review of theories and empirical studies related to organizational social responsibility and environmental management was carried out. This analysis made it possible to select a suitable research model for the Ecuadorian Land Force, based on the adaptation of the GIRA Plan, a model used successfully in Spain. This model integrates key aspects of sustainability, such as the management of end-of-life tires (NFU) and the adoption of environmentally responsible practices.

In addition, international standards, such as the Global Reporting Initiative (GRI) and sustainability reporting under the United Nations Global Compact (Carrillo and Galarza, 2022), which provide guidelines on how to manage social and environmental impact in complex organizations such as the Land Force (Ecuador), were evaluated.

2.2 Definition of Study Dimensions

Based on the bibliographic review and analysis of the data obtained, the following dimensions of the study were defined:

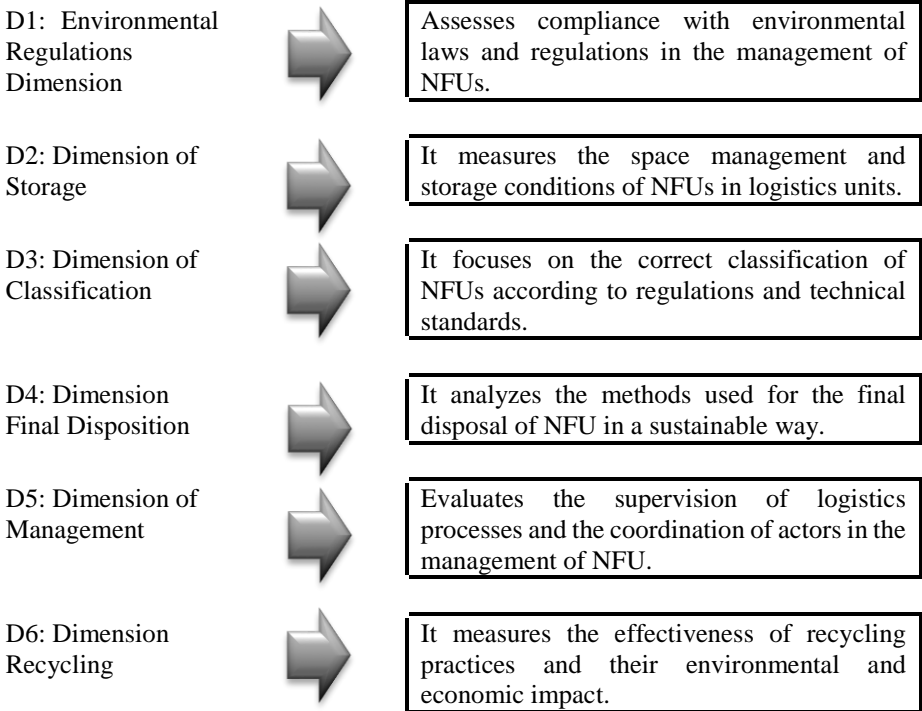


Figure 1. RS Dimensions for NFU

Note: Prepared by the authors

2.3 Questionnaire Design

The questionnaire consists of 53 questions divided into three main blocks:

- 28 dichotomous questions and 1 trichotomous question: These questions offer answers of 1 = Yes and 2 = No and, answers of a. in their entirety b. some certainty and c. none and, represent 50% of the total of the survey. They address key issues such as the generation of end-of-life tires in the units and the existence of management procedures that highlight information on the variables of storage, classification, final disposal, management, environmental regulations, and recycling.
- 18 questions on the Likert scale: They use a scale of 1 to 9, where options 1-3 indicate that the action does not apply, 4-6 reflect a basic application, and 7-9 indicate

a complete application. These questions address aspects such as the degree of application of environmental regulations, management and the effectiveness of the recycling practices of the NFU and has the weight of 31% of the survey.

- 11 additional questions: 4 questions with 3, 4 and 6 answer options and deal with the final disposal variable with weight of 7% of the total survey, 3 questions with answers of 2 and 4 alternatives that analyze the storage variable and give the weight of 5% of the survey, also, there are 2 chain-type questions that investigate the variable of environmental regulations and recycling and have a weight of 3% of the survey and, finally, there are 2 questions with 8 and 3 alternative answers and catalog the variables of environmental regulations and have the weight of 3% of the total survey. These questions explore specific aspects of storage, technical classification and final disposal of NFUs. They focus on evaluating the storage conditions, the characteristics of the place used and the final disposal methods used by the Institution.

2.4 Delphi method

The internal validation was carried out by a team of researchers from the University of the Armed Forces ESPE. Subsequently, external validation was carried out using the expert evaluation method, with professionals from Spain, Argentina, Colombia, Mexico, Ecuador and Peru, who evaluated the clarity, coherence and relevance of each item. This process ensured the applicability and effectiveness of the questionnaire.

Below is the table with the profiles of the experts involved in the external validation:

Table 1 Profile of external evaluators

Country	Evaluator Profile
Spain	An expert in sustainable development and CSR with experience in academia and consulting
Ecuador	A professional with experience in the implementation of CSR practices in mass consumption companies and public sectors. A professional expert in environmental management in military institutions.
Mexico	A researcher in logistics and environmental sustainability, with experience in impact assessment in the public and private sectors.
Argentina	An expert in social and solidarity economy, with a specialization in social and environmental impact assessment
Colombia	A professional specialized in environmental management studies in military institutions.

Note: Prepared by the authors

2.5 Instrument Reliability

Statistical tools, such as SPSS, were used to calculate Cronbach's alpha coefficients, which allowed the reliability of the instrument to be evaluated and to confirm that the dimensions and indicators are coherent and relevant to the study.

In addition to the evaluation of internal consistency, an exploratory factor analysis was performed to identify the factor loads of each item in the principal components. This analysis allows us to observe how well each item relates to the component to which it

is assigned and helps to identify if the items accurately measure the proposed dimensions.

The principal component extraction method and the Promax rotation were used to facilitate the interpretation of the components, since a correlation between them was anticipated.

3 RESULTS

3.1 Theoretical contributions on Corporate Social Responsibility (CSR)

Corporate Social Responsibility (CSR) involves the voluntary integration of social, environmental, and economic concerns into the operations of organizations. According to Bowen (1953), CSR considers the effects of its decisions on society, including the proper management of waste, such as end-of-life tires (ELUs). In the case of the Ecuadorian Land Force, the implementation of CSR not only focuses on social welfare, but also on the preservation of the environment through sustainable practices.

NFUs, due to their durability and strength, present a significant challenge if effective recycling and final disposal practices are not implemented. From the theoretical perspective of CSR, it is argued that an organization can improve its long-term sustainability by integrating environmental criteria into its operations. This allows not only to comply with environmental regulations, but also to improve operational efficiency and create value through the reuse of recycled materials, such as rubber and steel (Moratis, 2018).

In addition, organizations that implement CSR policies, such as the Ecuadorian Land Force, tend to improve their institutional reputation, aligning themselves with international standards such as ISO 26000 and the Global Reporting Initiative (GRI), which promote transparency in waste management and responsibility in sustainability (Global Reporting Initiative, 2021). Therefore, CSR not only implies compliance with social and environmental obligations, but also the search for sustainable solutions that generate benefits for both the organization and the environment (Carrillo, 2017).

3.2 CSR Models and Standards

One of the main components of the literature review is the identification and analysis of the most internationally recognized CSR models and standards. Some of them are described below:

ISO 26000, although not certifiable, is an essential guide for the implementation of Corporate Social Responsibility (CSR), especially in organizations that manage resources such as end-of-life tires (NFU). In the context of the Ecuadorian Land Force, this standard can serve as a framework to reduce information asymmetries and improve environmental sustainability. ISO 26000 encourages interaction with stakeholders and facilitates the development of customized policies for waste management, in line with international standards and best practices (Moratis, 2018; Hahn, 2020).

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This standard differs from others such as ISO 14001, which is certifiable, by focusing on moral principles and continuous improvement through dialogue. The implementation of ISO 26000 in the Land Force would allow structuring a CSR approach that encompasses the proper management of NFU, promoting transparency and sustainability. The standard offers guidance on how to embed socially responsible behavior into organizational operations, which aligns with the goal of reducing the environmental impact of NFUs, a key challenge in military logistics.

Adopting this standard not only improves operational sustainability, but also helps the Ground Force establish partnerships with private actors to maximize the benefits of recycling and proper disposal of NFUs. In addition, it fosters a robust organizational governance system that increases credibility and institutional commitment to CSR. In this context, ISO 26000 is a strategic tool for managing environmental responsibility, aligning operations with sustainability and transparency expectations at the international level (Webb, 2020).

The **AA1000 Assurance Standard** is a widely used framework for assessing, strengthening, and ensuring the quality and credibility of organizations' sustainability reporting. This standard focuses on three key principles of Corporate Social Responsibility (CSR): transparency, which ensures that organizations are accountable to stakeholders; responsiveness, which ensures that the concerns of these parties are addressed; and compliance, which seeks alignment with the standards to which the organization has committed itself (Accountability, 2003).

The central goal of the AA1000 standard is to ensure that organizations provide reliable reports that reflect not only legal compliance, but also their commitments to established policies and their reputation. This standard is essential for risk management and for improving the ethical and moral perception of the organization, which reinforces credibility and transparency, essential aspects of CSR (Accountability, 2003).

The AA1000 plays an essential role within CSR by providing a mechanism to ensure the quality of sustainability reports, which are key to demonstrating the organization's commitment to its stakeholders and society in general. In the context of the Ecuadorian Land Force, the adoption of this standard in the management of end-of-life tires (NFU) would improve accountability and responsiveness towards stakeholders, ensuring that actions aligned with sustainability are transparent and credible.

The **Spanish Association of Accounting and Business Administration (AECA)** defines Corporate Social Responsibility (CSR) as the voluntary commitment of organizations to social development and the preservation of the environment, based on responsible behavior towards the individuals and groups with which they interact (AECA, 2003). The central objective of this standard is to promote the scientific development of CSR, facilitate its implementation in organizations, and encourage collaboration between people and entities dedicated to CSR, through the dissemination of management techniques focused on this approach.

Within the framework of waste management, such as end-of-life tyres (ELUs), the AECA social indicators provide a structured basis for assessing the social and environmental impact of an organisation's operations. In the context of the Ecuadorian

Land Force, the application of these indicators would improve the measurement of its contributions to social and environmental well-being, ensuring that its commitment to sustainability is measurable and transparent.

The **Ethical and Socially Responsible Management System (SGE 21: 2008)** is a framework that integrates social, labor, environmental and human rights concerns into organizational management. This system focuses on compliance with current legislation, ethical management policy, dialogue with stakeholders, and continuous improvement (INGECAL, 2011). In addition, the Ethos Indicators allow companies to assess the level of development of their CSR strategies, helping them to measure their relationship with all their audiences and their social and environmental impact (Ethos, 2005).

The **Global Compact Guide** states that business practices based on universal principles contribute to the construction of a more stable and equitable global market, fostering prosperous societies (Global Compact, 2013). To achieve this, companies must integrate these principles into their strategy, management, and culture. These principles are organized around four thematic axes: human rights, working conditions, environment and anti-corruption. The implementation of these pillars is essential to promote sustainability and social responsibility at the global level.

The **Global Reporting Initiative (GRI)** provides a framework for sustainability reporting focused on three main dimensions: economic, environmental, and social. The GRI does not define a specific concept of social responsibility, but focuses on sustainability, understood as the impact of business decisions on the local, regional, and global environment (GRI, 2018). In particular, the 300 - GRI standard, which refers to the environmental dimension, covers topics such as the consumption of natural resources, waste and effluent management, biodiversity and greenhouse gas (GHG) emissions. These indicators help organizations measure, manage, and report the environmental impact of their activities, ensuring that efforts are made to mitigate their ecological footprint.

In the context of the management of end-of-life tires (NFU) by the Ecuadorian Land Force, the application of the GRI 300 can be key to monitoring and reducing the environmental impact of logistics and operational processes. Through the GRI 301 (materials), GRI 305 (emissions) and GRI 306 (waste) standards, the Land Force can develop a detailed report that not only measures resource consumption and waste generation, but also the impact of emissions generated by mismanagement of NFUs and the need to implement more sustainable solutions.

3.3 Integrated Waste Management Plan of Aragon (GIRA)

The Integrated Waste Management Plan of Aragon (GIRA) is an exemplary model that has proven its effectiveness in waste management, particularly in the handling of end-of-life tyres (NFU). Since its implementation, it has generated significant economic benefits, estimated at 833 million euros, and has promoted job creation, thanks to collaboration between the public and private sectors. This plan establishes a management framework that prioritises the classification, storage and final disposal of waste, with a clear focus on reducing environmental impact.

One of the most important aspects of the GIRA Plan is its commitment to the circular economy and waste prevention, which has made it possible to minimise the amount of waste destined for landfill and optimise its recycling. The model also incorporates strict environmental regulations and establishes indicators based on scientific evidence, allowing continuous monitoring and ensuring that sustainability objectives are met (Government of Aragon, 2021).

Key principles governing this model include:

1. Protection of human health and the environment: Ensures that waste management does not affect human health or the environment.
2. Waste hierarchy: Following Directive 2008/98/EC, it prioritises the prevention, reuse, recycling and ultimately disposal of waste.
3. Polluter pays principle: Ensures that those responsible for pollution bear the associated costs, thus promoting responsible management.
4. Fight against climate change: Proper waste management effectively contributes to the reduction of greenhouse gas emissions.

The GIRA Plan 2018-2022 has also established action programmes that cover different types of waste and are applied throughout the territory of Aragon, with the flexibility to adapt to European and national regulations. In addition, it encourages citizen participation and transparency in waste management, providing access to information and allowing all actors involved to assume their share of responsibility in the waste prevention and management chain (Environmental Sciences, 2018). The implementation of this plan has resulted in the consolidation of a management network adapted to the socio-economic and territorial conditions of Aragon, promoting greater environmental awareness and generating opportunities for employment in the recycling and waste recovery sector.

3.4 Validation of the Questionnaire

The instrument was designed incorporating theoretical contributions from various regulations and frameworks that address organizational social responsibility (OSR) and environmental sustainability, which were analyzed in the previous sections.

Once the general objective of the questionnaire has been defined and the specific dimensions and indicators have been detailed, work meetings are held by the team responsible for preparing the first version of the questionnaire. From here, the questions corresponding to each indicator are written.

In the writing of the questions, it is decided whether to use closed items, open items and questions with a Likert scale, considering the advantages and disadvantages of each type. Questions are selected based on the expected type of response, as well as the function and nature of the content. All items are designed briefly to avoid confusion or excess of time for the respondent.

The order of the items is taken care of, placing identification questions in the first block that facilitate the respondent's concentration. A "funnel" approach is then employed, starting with the most general items and working their way up to the more specific ones, thus avoiding that important questions are placed at the end.

Next, a specification table is drawn up that includes the corresponding dimensions, variables, indicators and number of items. This procedure, together with validation by judges, allows the validity of content to be evaluated, ensuring that the dimensions are covered by appropriate questions. As a result of this process, the first version of the questionnaire is developed. It is important to note that the final version was achieved after 5 iterations of the initial questionnaire.

Table 2. Dimensions, variables and indicators

Dimension	Variable	Indicators	Number of items
Environmental regulations	Application of Environmental Regulations	1. Compliance with laws and regulations 2. Existing procedures 3. Knowledge of regulations	6
Storage	Storage Conditions	1. Storage space and conditions 2. Cleaning methods 3. Marking and wrapping tires	7
Classification	NFU Rating	1. Proper classification 2. Delivery to the manager	2
Disposal	NFU Disposition Methods	1. Use for recycling, sale or shipment to landfill 2. Component recycling	6
Management	NFU Management	1. Knowledge of procedures 2. Importance of regulation 3. Management methods applied	11
Recycling	Recycling practices	1. Degree of application of recycling 2. Feasibility and usefulness of recycling methods	12
Total			50

Note: Prepared by the authors

3.4.1 Internal Validation

During the questionnaire review process, the project's research team identified several areas for improvement that were critical to ensure the effectiveness of the instrument. First, it was noted that the initial questions lacked clarity and could lead to confusion among respondents. To address this, the questions were rewritten to ensure that each one was straightforward and understandable.

Additionally, it was noted that some items did not adequately reflect the specific context of the Land Force. To solve this, relevant examples were added that illustrate situations specific to the institution, thus facilitating a better connection with the respondents. Another highlight was that several technical terms used might not be familiar to all participants. In response, simple and accessible definitions were incorporated into the questionnaire instructions, ensuring that all respondents could easily understand what they were being asked.

The team also found that the original rating scale did not capture the diversity of expected responses. As a result, a new scale was designed that allows a better capture of the frequency and intensity of the practices observed in the management of NFU. In addition, the lack of a specific evaluation of communication and accountability practices in the management of NFU was identified. Questions were included that inquire about the effectiveness of these practices, which is essential for transparency in the operations of the Land Force.




3.4.2 External Validation

The external validation of the questionnaire was carried out using an approach that involved critical evaluation by experts. Six experts from Spain, Argentina, Colombia, Ecuador, and Peru evaluated the questionnaire, providing detailed feedback on the items based on their sufficiency, clarity, coherence, and relevance.

As we have mentioned above, content validity refers to the degree to which the process of moving from the theoretical to the empirical measures the concept in question (Ruiz, 2014). To do this, in our questionnaire, we used an item analysis, consisting of the evaluation of the contents by a group of experts in the area to be treated (validation by judges). Content validity is essential when making inferences or generalizations from the results obtained with the questionnaire.

In total, six experts from different areas participated, based on their observations, a set of changes were introduced, mainly referring to the content and structure of the questionnaire. Thus, the second version of the instrument was developed.

The results of the evaluation carried out by these experts are presented below, grouped by the dimensions of the questionnaire designed to evaluate the management model of end-of-life tires (NFU) in the Ecuadorian Land Force:

D1: Environmental Regulations Dimension		The experts highlighted that most of the items related to compliance with environmental regulations obtained high scores in sufficiency and relevance.
D2: Dimension of Storage		In this dimension, the experts noted that storage conditions are adequate, but recommended more frequent monitoring to ensure that best practices are maintained. The scores reflect a positive consensus on the management of the space.
D3: Dimension of Classification		The correct classification of NFU was considered essential, and the experts proposed the implementation of periodic training for the personnel involved. The feedback received high scores in clarity and relevance, indicating a good perception of the items.

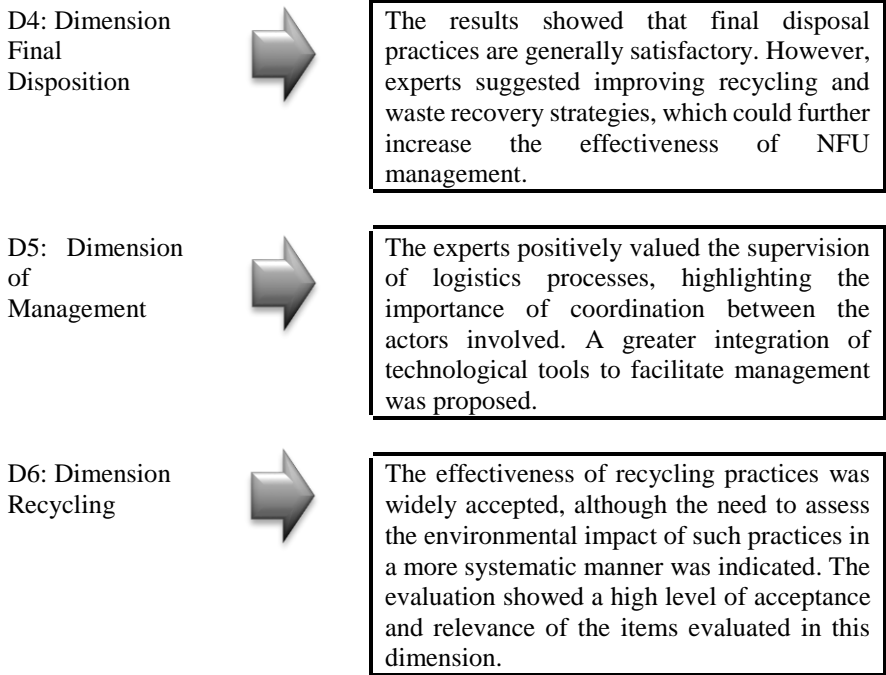


Figure 2. Expert Validation

Note: Prepared by the authors

The results obtained in Table 3 reflect the robustness of the questionnaire and its ability to capture relevant information on the management of NFU in the Ecuadorian Land Force. The feedback provided by the experts allowed necessary adjustments to be made to ensure that the questionnaire is an effective tool in data collection, thus facilitating the development of the proposed management model.

Table 3 Evaluation Results

Dimension	Sufficiency	Clarity	Relevance
Environmental Regulations	4.0	4.0	4.0
Storage	3.9	4.0	4.0
Classification	4.0	4.0	4.0
Final Disposition	3.8	3.9	3.9
Management	4.0	4.0	4.0
Recycling	4.1	4.0	4.1

Note: Prepared by the authors based on experts

3.4.3 Statistical analysis of validation

Reliability

The questionnaire was applied to a sample of 120 employees with a double objective: to test their general reliability and by dimensions (Ruiz Bueno, 2014) and to collect

information on the NFU management model. Thus, the purpose of evaluating the reliability of the questionnaire was:

- Check the reliability of the instrument (general and specific) to investigate the end-of-life tire management model.
- Determine that the dimensions and indicators (items) are coherent and relevant to inquire about the topic.
- Analyze whether the indicators (items) allow for the collection of adequate information for research on the subject.

Based on the analysis of the data generated by the available sample, the evaluation instrument designed for the management of end-of-life tires (NFU) in the Ecuadorian Land Force was validated, addressing the underlying structure of the evaluated construct. For this purpose, an exploratory factor analysis was applied with the aim of determining the main components that explain most of the variance in the data. This analysis was carried out using SPSS version 22 software.

Table 4 Total variance explained

Component	Initial Self-Values	Sums of loads squared from extraction	Sums of Charges Squared from Rotation
	Total	% variance	Cumulative %
1	8.324	41.618	41.617
2	2.454	12.272	53.890
3	1.831	9.157	63.047
4	1.338	6.689	69.736
5	1.073	5.363	75.097
6	0.846	4.229	79.323

Note: Prepared by the authors in SPSS 22

The principal component extraction method was used and, to improve interpretability, a Promax rotation was applied, since a correlation between the components was anticipated. The results obtained reflect that the instrument has a clear and adequate structure, and the Kaiser-Meyer-Olkin (KMO) sample adequacy measure reached a satisfactory value, supporting the relevance of factor analysis. In addition, Bartlett's sphericity test was highly significant ($p < .001$), indicating that the correlations between the items are large enough to proceed with factor analysis.

The factor analysis allowed the identification of six main components that explain a total of 79.323% of the accumulated variance. The following are the components obtained, their initial eigenvalues, the variance explained by each one, and their total cumulative:

Component 1: Management Dimension

This component has an initial eigenvalue of 8.324, explaining 41.617% of the total variance. After rotation, it explains 23.107% of the variance. It groups items related to the management and logistical supervision of the NFU, suggesting that these items are highly correlated with each other and are the most representative of the proposed

model. This reflects the ground force's organizational capacity to manage these resources efficiently.

Component 2: Environmental Regulatory Dimension

This component has a self-value of 2.454, explaining 12.272% of the total variance. After rotation, it explains 13.231% of the variance. This component is related to compliance with environmental regulations, underscoring the importance of monitoring regulations in the management of NFUs, which ensures that operations are aligned with the principles of social responsibility within the military field.

Component 3: Classification Dimension

This component has an eigenvalue of 1.831 and explains 9.157% of the total variance. After rotation, it explains 12.624% of the variance. This set of items is linked to the classification of the NFU, highlighting the importance of correct separation and treatment of tires according to the established technical regulations.

Component 4: Storage Dimension

With a self-value of 1.338, this component explains 6.689% of the variance. After rotation, it explains 11.548% of the variance. It is associated with the proper storage of NFUs, reflecting the importance of having adequate spaces and conditions that comply with safety and sustainability regulations, ensuring the effective control of end-of-life tires.

Component 5: Recycling Dimension

This component has an eigenvalue of 1.073, explaining 5.363% of the total variance. After rotation, it reaches 11.463% of the variance. The items of this component are related to the management of NFU recycling, addressing the efficiency of recycling processes and their environmental impact, promoting sustainable practices within the organization.

Component 6: Final Disposal Dimension

This component has an eigenvalue of 0.846 and explains 4.228% of the total variance. After rotation, its explained variance is 7.355%. This component focuses on additional practices for the final disposal of waste, ensuring that complementary measures for the management of NFU are sustainable, closing the cycle of management of this waste.

All six components achieved self-values greater than 1, making them eligible to be retained. These components are interpretable and show a factor structure consistent with the expected theoretical dimensions, such as compliance with regulations, efficiency in logistics management, and the adoption of sustainable practices in the handling of end-of-life tires.

Table 5 Interpretation of the components

DIMENSION	COMPONENT	INTERPRETATION
Management	Component 1	It is the most significant component in terms of explained variance. It is associated with the supervision and coordination of the management of the NFU, reflecting the

		organizational capacity to efficiently manage these resources.
Environmental regulations	Component 2	It highlights the importance of environmental regulations. It underlines the need to ensure that the management of NFUs is aligned with current regulations, reinforcing the principles of social responsibility.
Classification	Component 3	It reinforces the importance of proper logistics practices, especially in relation to the classification of NFUs, ensuring that it is done correctly and following established technical standards.
Storage	Component 4	This component focuses on the storage of NFUs, highlighting the importance of having adequate spaces and conditions to maintain safety and sustainability in the logistics process.
Recycling	Component 5	It addresses the impact of recycling on NFU management, a key dimension in environmental and economic sustainability. This component measures the effectiveness and implementation of recycling practices within the organization.
Final Disposition	Component 6	It highlights the relevance of complementary practices for the final disposal of waste, ensuring that all stages of the NFU management process are executed in a sustainable and efficient manner.

Note: Prepared by the authors in SPSS 22

Finally, an internal consistency analysis was performed by calculating Cronbach's Alpha coefficients at the global level and for each of the dimensions that compose it. This methodological exercise ensures the consistency of the questionnaire for empirical data collection (Taber, 2018).

Table 6 Cronbach's Alpha by Dimensions

Dimension	Cronbach's Alpha
Environmental regulations	0.85
Storage	0.92
Classification	0.87
Final Disposition	0.89
Management	0.95
Recycling	0.91

Note: Prepared by the authors in SPSS 22

The results obtained from Cronbach's alpha indicate that the questionnaire is a reliable instrument to evaluate the different dimensions of the NFU management model. High values of internal consistency suggest that the items are coherent and effectively measure the constructs they represent. This pilot application phase not only validates the structure of the questionnaire, but also provides a solid basis for its implementation in broader data collection in future research.

4. Conclusions

The validation of the questionnaire through a rigorous methodological approach ensures that the items are relevant and effective in assessing the management of end-of-life tires in the Ecuadorian Land Force. Cronbach's high alpha coefficients reflect strong internal consistency, supporting its suitability for data collection on logistics practices. Therefore, validating a research instrument is an essential process to ensure that the conclusions are sound and adequately represent reality, providing a reliable basis for informed decision-making.

The participation of experts, both internal and external, in the validation process has been instrumental in improving the clarity and relevance of the items, ensuring that they adequately reflect the specific context of the Ecuadorian military institution.

The exploratory factor analysis allowed the identification of six main components that explain 79.323% of the variance, which shows that the instrument is suitable for measuring logistics practices related to NFUs. The Promax rotation improved the interpretability of the components, ensuring that key dimensions were correctly identified and understood.

Cronbach's alpha coefficients greater than 0.85 in all dimensions confirm that the instrument is reliable and consistent. Every component measured, from regulatory compliance to recycling, showed high internal consistency.

The instrument is not only useful for assessing current practices, but also for identifying areas for improvement in NFU management. This study provides a solid basis for future research and the implementation of sustainable strategies, aligned with international regulations and principles of social responsibility.

It is recommended to carry out studies on the impact of the proposed management model on reducing the environmental footprint associated with end-of-life tyres in military contexts. In addition, it would be valuable to investigate the feasibility of applying this model in other defense institutions in the region.

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