
The State of the Art in Sustainable Logistics: Economic and Military Perspectives

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Abstract

The sustainable approach to logistics is emerging as a necessity in both the economic and military domains. This study aims to explore the current state of knowledge in the field of sustainable logistics within these spheres of activity, in order to identify gaps that should be addressed by future research. Based on a literature review methodology, the study brings to the forefront five thematic areas that have been addressed so far in the economic field, highlighting the need to extend them into the military domain as well. The analysis shows that the digitisation of logistics and the implementation of environmentally friendly technologies, which also reduce the negative impact on the health of end users, are two essential conditions for the transition toward sustainability. At the same time, the study emphasises the importance of an interdisciplinary approach and of researching the social impact of sustainable logistics, including the dimension related to humanitarian actions involving military forces. The main conclusion points to the need for clearly defining the concept of sustainable military logistics, taking into account developments in the economic environment and operational requirements.

Keywords:

logistics; defence; sustainability; sustainable development;
alternative solutions; technologies.

Article info

Received: 12 April 2025; Revised: 5 May 2025; Accepted: 16 May 2025; Available online: 27 June 2025

Citation: Hrab, D.E. 2025. "The State of the Art in Sustainable Logistics: Economic and Military Perspectives".
Bulletin of "Carol I" National Defence University, 14(2): 223-236. <https://doi.org/10.53477/2284-9378-25-25>



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Sustainability is a concept common to both economic and military fields. From an economic perspective, it represents the ultimate goal of the sustainable development process (Blewitt 2018, 4-74), a higher form of economic development (Pezzey 1992, 10). This is characterised by a shift away from the sole objective of generating economic profit and by an increased concern for the environment and people, in order to ensure the long-term availability of natural resources (United Nations 1987, 16). In the military field, sustainability refers to the ability to support an operation with adequate combat power by providing the necessary human and material resources throughout its entire duration (NATO Standardization Office 2022, 399), with military logistics playing a key role.

Thus, in both fields, the concept of sustainability is related to the uninterrupted availability of necessary resources, the difference being that, in the military domain, sustainability focuses on the proper conduct of military operations, while the perspective of environmental protection and care for communities is less prominent. Nevertheless, considering that one of the 17 Sustainable Development Goals (SDGs) – specifically SDG no. 16 refers to ensuring peace, justice, and strong institutions (United Nations 2015, 25-26), it can be inferred that the military organization can contribute to creating the conditions for peace and, thereby, to those necessary for sustainable development. However, the potential for a broader contribution by the military organisation to the achievement of other SDGs should not be underestimated.

As for 2017, the issues related to logistics management and supply chain ranked among the top ten thematic areas of interest for researchers aiming to expand the knowledge in the field of sustainable development (Wichaisri and Sopadang 2017, 4). From the perspective of the integrated approach to the three pillars of sustainable development (economic, social, and environmental) (United Nations 2015, 1), economic entities have concluded that adopting a sustainable approach to logistics management can generate benefits both by increasing competitive advantage and by reducing environmental impact (Wichaisri and Sopadang 2017, 4-12), as well as by improving the efficiency of supply chains (Stroufe 2018, 326-329).

In the military domain, the way logistical support is provided can significantly contribute to the retention of human resources within the organisation (Vie, Trivette and Lathrop 2021, 28), thus offering benefits in terms of the sustainability of human resources. Moreover, the pursuit of sustainable logistical solutions is highlighted as a goal in strategic-level documents. For example, NATO envisions the development of environmentally friendly systems based on low-carbon technologies (NATO 2021), the use of alternative fuels (NATO 2020, 39-42), and contributions to enhancing the resilience of water and food sources (NATO 2016). The transatlantic vision is also shared at the EU level, where emphasis is placed on the procurement of environmentally friendly equipment, as well as on the requirement that the armed

forces of the member states develop strategies to combat climate change ([European Union 2022](#), 5). Furthermore, the need for a sustainable approach at the EU level is explicitly stated in the recently issued White Paper. This document reflects ideals specific to sustainable development, such as improving the quality of life for European citizens and enhancing the security environment ([European Commission 2025](#), 1).

Previous research also states that the need for sustainable military logistics is a real one. For instance, researchers point out that the successful completion of missions depends on the adoption of sustainable logistics practices, such as the use of technologies that reduce the need for petroleum-based supplies and the minimisation of material resource deployment ([Mosher, et al. 2008](#), 51). In addition, sustainability is seen as a way to prevent illness among military personnel, caused by toxic spills, exposure to disease-carrying insects, poor sanitary conditions, and effects generated by improper hazardous waste management, which can also be exploited by the adversary ([Mosher, et al. 2008](#), 5-6). As a result of the negative effects caused by extreme weather events, which sustainable development also aims to combat ([United Nations 2015](#), 2-8), logistical processes such as resupply or maintenance can be disrupted due to breaks in the military supply chain ([Best, et al. 2023](#), 22,73).

Based on the lessons identified by the U.S. military in Afghanistan and Iraq, shifting logistics toward sustainable solutions could help reduce equipment and personnel losses, as well as the massive consumption of fossil fuels ([Harrington 2016](#)). Consequently, there is a need to rethink the current methods of providing logistical support by adopting solutions that reduce the logistical footprint and carbon emissions, at the same time ([Belcher, et al. 2019](#), 75-76). For example, the availability of alternative sources of water, electricity, and fuel could enhance the sustainability of logistical support ([Cooper 2019](#), 4-7). As a result, the importance of this scientific endeavour lies in the need to establish a starting point for the implementation of the sustainable logistics objective, a goal that is increasingly evident both in civil society and in the military sphere.

In this context, the present study aims to explore the current state of knowledge in the field of sustainable logistics, in order to guide military logisticians' actions toward defining relevant and timely research problems ([Kumar 2011](#), 17-27). To achieve this objective, the study employs the literature review method, following two main stages: 1) exploring the current state of knowledge and key scientific concerns in the civil domain of sustainable logistics; 2) analysing relevant studies in the field of sustainable military logistics.

Thus, using "sustainable logistics" as a search keyword in databases such as Google Scholar, ProQuest, Scopus, and Web of Science, several relevant studies were identified in the form of scientific articles or book chapters. The selection was based

on scientometric testing, taking into account aspects such as: the number of citations, the journal's impact factor relative to its field, the geographical distribution, and the preferences of researchers within the domain (Grigore 2021, 1-5). Studies with more than eight citations were considered. In the following sections, corresponding to the two stages previously mentioned, the content of these studies is analysed in order to identify the most significant findings and to establish the current state of knowledge in the field of sustainable logistics in the military area.

State of research in the civilian field of sustainable logistics

Most studies on sustainable logistics were also conducted through the literature review method, and were focused on five main thematic lines. The first three addressed sustainable logistics in general, with particular emphasis on the environmental aspect (Ren, et al. 2019, 1-20), as well as alternative solutions for reducing the carbon footprint (Awwad, Shekhar and Iyer 2018, 584-591). The other two addressed the benefits of Industry 4.0 technologies in enhancing logistics sustainability (Sun, et al. 2022, 9560-91); (Grzybowska, Awasthi and Sawhney 2020, 1-18), and decision support systems in aid of sustainable logistics (Qaiser, et al. 2017, 1376-1388).

The first of the selected studies analysed articles in peer-reviewed journals published between 1999 and August 2019, identified in the Scopus and Web of Science databases. Using bibliometric analysis tools such as VOS (Visualization of Similarities), the study highlighted the growing interest in this field (Ren, et al. 2019, 2-4), as shown in Fig. 1.

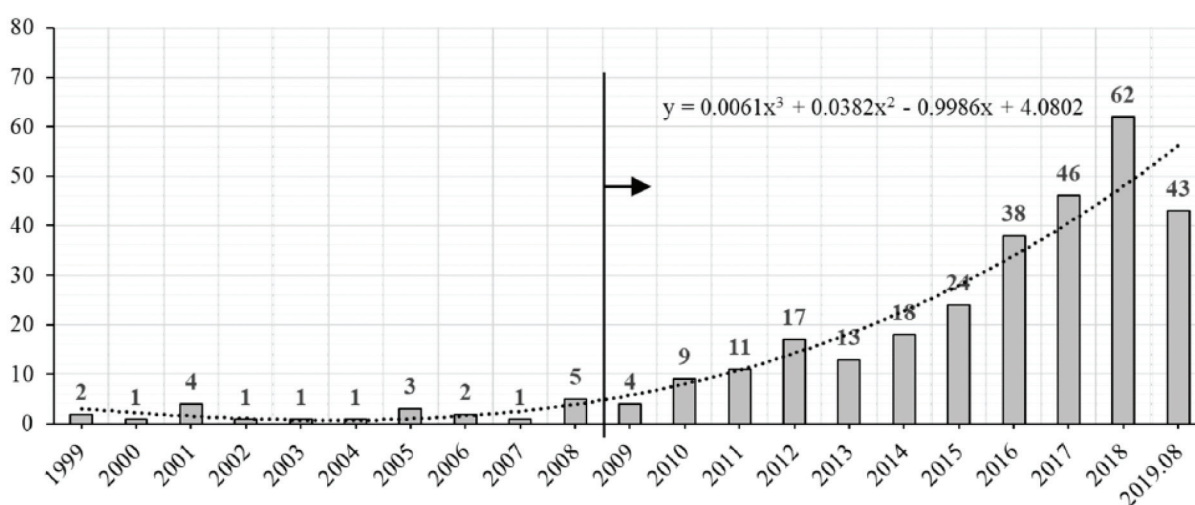


Figure 1 The evolution of publications in the field of sustainable logistics, from 1999 to August 2019 (Ren, et al. 2019, 5)

By analysing a wide range of studies dedicated to sustainable logistics, it becomes evident that the aforementioned study is particularly relevant, serving as the foundation for subsequent research, as shown in Figure 2.

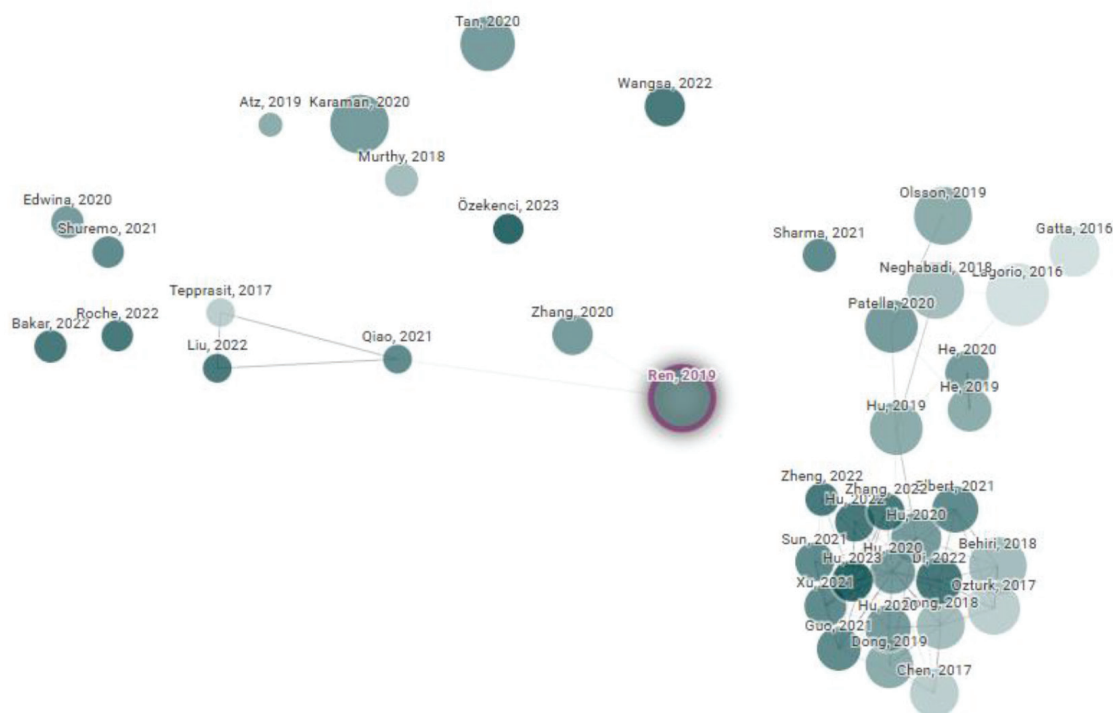


Figure 2 Relevant publications on the topic of sustainable logistics (2016–2023).

Source: *Own analysis*, using <https://www.connectedpapers.com/main/f90ddfa099de3c61a5ecb275d4a04e74323b2cd7/A-Systematic-Literature-Review-of-Green-and-Sustainable-Logistics%3A-Bibliometric-Analysis%2C-Research-Trend-and-Knowledge-Taxonomy/graph>, accessed 10.03.2025

The study highlighted several subthemes within sustainable logistics research, corresponding to the environmental dimension of sustainability. The fifteen most relevant papers analysed by the authors, with citation counts ranging from 73 to 330, addressed topics such as green logistics, reverse logistics, and the environmental aspect of sustainable logistics. Most research efforts were concentrated in Europe, but those from China and America were also noteworthy (Ren, et al. 2019, 8-11). By thematically grouping the analysed studies, it becomes apparent not only that there is a strong focus on the environmental side of logistics sustainability, but also that there is a limited number of studies offering an integrative perspective on this field.

Within the thematic area focused on environmental protection, also, another study relevant to the issue of sustainable logistics suggests the use of green logistics mechanisms to reduce carbon emissions. The authors highlight the role of the “last-mile logistics” concept – which refers to the final segment in the supply chain specific to e-commerce (between the distributor and the end consumer) – in the generation of greenhouse gases, while also presenting solutions and strategies for reducing these emissions (Awwad, Shekhar and Iyer 2018, 586).

Regarding the negative environmental impact of this segment of the supply chain, the authors discuss solutions such as the use of alternative fuels, electric vehicles, urban distribution centres, and technology dedicated to optimising route selection ([Awwad, Shekhar and Iyer 2018](#), 586). The focus is placed on analysing the characteristics of transport vehicles and delivery routes in order to choose the option that ensures the lowest fuel consumption, and, thus, the smallest carbon footprint ([Awwad, Shekhar and Iyer 2018](#), 586). The proposed solutions are not universally applicable; the authors note that, under different circumstances, more efficient alternatives may exist (for example, hybrid vehicles may have a lower carbon footprint and do not require long battery charging times like the electric ones) ([Awwad, Shekhar and Iyer 2018](#), 586). At the end of the study, authors highlight the need to identify barriers to implementing these solutions, as well as the importance of their comprehensive application in order to achieve conclusive results.

As time went by, beneficial changes have taken place, as evidenced by the existence of a study analysing the literature on the application of Industry 4.0 technologies for logistics sustainability, based on bibliometric and content analysis of publications. The issue of adopting technologies that facilitate the implementation of sustainability has thus emerged as a second main thematic area. According to the authors' analysis, 40% of researchers' concerns focused on the digitalization of logistics systems; 22.6% on interdisciplinary studies; 20.9% on sustainable transportation; 10.4% on sustainable production and procurement objectives; and the narrowest area of focus was sustainable warehousing, accounting for only 5.2% ([Sun, Yu, et al. 2022](#), 9560-91).

Concerning the practical application of technologies for achieving logistics sustainability, the study highlights twelve innovative solutions explored by researchers between 2017 and 2020 ([Sun, Yu, et al. 2022](#), 9560-91). This reflects a strong orientation of civil logistics toward harnessing the benefits of digitalisation and technological advancement to achieve sustainability. Despite the numerous concerns regarding the importance of implementing Industry 4.0 technologies for reaching sustainability goals, the study points out a lack of focus on identifying the challenges brought by this transformation ([Sun, Yu, et al. 2022](#), 9560-91). In other words, while considerable scientific effort has been devoted to theorising and demonstrating the benefits of integrating these technologies, the measures that need to be taken and their consequences have not been identified, representing significant gaps in the body of knowledge on sustainable logistics.

As a result, the authors propose the following future research directions: complementing the technological vision of Industry 4.0 with the human-centred approach of Industry 5.0 to support the social dimension of sustainable logistics; implementing decision-support algorithms that take into account the three dimensions of sustainable development; the need for in-depth analysis of the environmental footprint generated by the energy used for the production and recycling of goods; developing analytical models to optimize the implementation of

Industry 4.0 technologies; using digitalization to increase the autonomy of logistic systems; leveraging the advantages of implementing semi-autonomous transport solutions; paying greater attention to how Augmented Reality (AR) and Additive Manufacturing (AM) technologies can enhance logistics sustainability; developing the sustainable dimension of reverse logistics; and using Industry 4.0 Technologies to increase resilience under special conditions, such as pandemics (Sun, Yu, et al. 2022, 9560-91). Analysing the findings of this study, one can observe the enormous potential of innovative technologies to enhance logistics sustainability — a goal that seems almost impossible to achieve without implementing measures for the digitalisation of logistics.

Closely related to the perspective offered by Industry 5.0, a concept aligned with sustainable logistics is Logistics 5.0, which is focused on identifying environmentally friendly packaging, transportation, and storage solutions, as well as increasing care for consumers (Trstenjak, et al. 2022, 2). However, the technology component remains important in Logistics 5.0 as well, with studies showing that both the COVID-19 pandemic and the Russia-Ukraine war have highlighted the urgency of adopting smart logistics solutions (Jafari, Azarian and Yu 2022, 1-27). Therefore, sustainable logistics must address actions across the three pillars of sustainable development, as well as those specific to smart logistics.

Another paper focused on literature analysis concerning sustainable production and logistics in the context of the Fourth Industrial Revolution reinforces the role of automated processes in the implementation of sustainable management (Grzybowska, Awasthi and Sawhney 2020, 1-18). The mathematical and statistical techniques used by the authors also led to the identification of the historical evolution of the two concepts: sustainable production has been studied since 1987, while sustainable logistics emerged as a concept in 2004, being associated with green industry and the circular economy (Grzybowska, Awasthi and Sawhney 2020, 5). The study was based on a sample of 892 scientific papers produced by researchers from 91 countries, most of which were published in scientific journals, with the Journal of Cleaner Production and Sustainability ranking first and second. The authors also identified several phases in the academic interest in sustainability: the activation period (1980-2006), the growth period (2007-2015), and the expansion period (2016-2018). Sustainable logistics belongs to the third period, during which a trend toward replacing the term with “sustainable supply chain” was observed (Grzybowska, Awasthi and Sawhney 2020, 15).

The third important theme in the field of logistics sustainability, addressed in studies based on the analysis of relevant literature, is represented by decision support systems. From this perspective, as of 2017, researchers concluded that the benefits of using these systems for the implementation of sustainable logistics are real, considering the complexity of the decision-making process at the strategic, operational, and tactical levels, in the context of sustainable development (Qaiser, Ahmed, et al. 2017, 1).

Furthermore, the necessity of using a sustainable model for choosing between local and external suppliers is brought into discussion – one that allows for the consideration of the three dimensions of sustainability when analysing criteria such as costs and carbon emissions generated from the perspective of various modes of transportation and other logistics operations ([Katirae, et al. 2024](#), 13).

The tendency to identify tools that assist decision-makers in the effort to optimise costs and reduce the environmental impact of logistics, as well as the insufficient attention paid to the social dimension of sustainability ([Qaiser, Ahmed, et al. 2017](#), 6) has also been highlighted. Thus, there is a need for a holistic exploration of the feasibility of using decision-making tools to achieve sustainable logistics ([Qaiser, Ahmed, et al. 2017](#), 7). It is, therefore, essential to preserve all guiding principles of sustainable development, as an approach focused solely on one of its dimensions is insufficient.

From the perspective of strengthening the social dimension of sustainable logistics, more recent studies address a fourth thematic area, showing that personnel working in this field must benefit from decent, properly regulated working conditions, as they are involved in a wide range of operations, such as: storage management, route planning, production planning and scheduling, workforce management, and lot sizing ([Prunet, et al. 2024](#), 18-19).

In addition to the studies previously presented, there have also been other research concerns, like humanitarian logistics, which is closely linked to the social dimension of sustainable logistics, thus representing the fifth main theme in this domain. The author investigates the possibility of considering sustainable humanitarian logistics as a distinct research field, focusing on the principles that should be upheld and the concrete possibilities for implementation. In this context, a systemic approach is highlighted as a favourable factor for implementing sustainability in humanitarian logistics, allowing for the consideration of all pillars of sustainable development ([Remida 2015](#), 11-29).

The author also highlights three levels of objectives that can be targeted: at the strategic level, the integrative approach to the pillars of sustainable development; at the tactical level, which is closest to humanitarian logistics and its beneficiaries, the humanitarian actions; and at the “operational” level, systemically approached logistics, including planning, procurement, and other activities related to logistics subsystems ([Remida 2015](#), 21).

In addition, the study draws attention to several characteristics of sustainable humanitarian logistics, highlighting its potential to broaden the spatial and temporal horizons, as well as the requirement to consider all involved stakeholders. For the sustainability of humanitarian logistics, the author emphasises the importance of applying principles such as: an interdisciplinary approach, a dual vision (immediate response and long-term effect, private and public effort), and the use of analogies

with other logistics systems from different fields, such as the military system. Although the study highlights the need to achieve long-term effects through joint exercises with military forces and by utilizing existing military infrastructure, it does not explore the possibility of adopting sustainable logistics models from the military sector, nor does it detail the sustainability of military logistics as a potential example for humanitarian logistics ([Remida 2015, 26-27](#)).

Remaining within the sphere of humanitarian logistics, a more recent study, based on modelling and a sociological questionnaire, advocates for the inclusion of disaster-related logistics (applicable in cases of natural or human-made disasters) in university programs, as a means of achieving sustainability, given the shortage of trained logisticians and the widespread use of untrained volunteers. At one point, the author concludes that the use of professionally trained logisticians can bring sustainability to any organisation, an observation that highlights the significant role of logistics in sustainable development. One of the limitations of this study is that it was conducted with respondents from the academic environment, without considering other actors such as those from military organisations, who are often involved in disaster relief activities and support for the affected population ([Khan, et al. 2020, 1-30](#)). Therefore, it can be considered that humanitarian activities within military logistics could be classified under the social dimension of sustainable military logistics, helping to complete the framework of this emerging concept.

State of the art in the field of sustainable military logistics

In the second stage, aimed at identifying the state of knowledge in the field of sustainable military logistics, searches in databases such as Google Scholar and ProQuest were conducted. The identified studies were also ranked according to their contribution to advancing the state of knowledge, taking into account criteria such as the number of citations, year of publication, and the impact of the journals in which they appeared. Since, from a military perspective, the results were not as numerous as those found in the field of economically sustainable logistics, no publications analysing the relevant literature in this domain could be identified. The following section presents the main findings from the analysis of relevant works that have addressed the issue of sustainability within military logistics.

A valuable study for military logisticians aiming to improve the efficiency and sustainability in this field highlights the importance of multicriteria analysis in decision-making regarding the selection of suppliers and supply routes for military forces in the Iraq theatre of operations. The authors provide a definition of the sustainability of supply routes, which involves the rational use of resources, based on technological development, institutional adaptation, and investments ([Alazzawi and Žak 2020, 578](#)). Although the definition is general, the reference to resources, technology, institutions, and investments partially situates it in the context of sustainable development.

This aspect also emerges from the analysis of the criteria considered in the decision-making process, which are explicitly formulated around the ideas of economic efficiency and environmental protection ([Alazzawi and Žak 2020, 579](#)) However, there is a lack of reference to the social dimension of sustainable development, as aspects related to the human resources involved in establishing logistic support corridors and selecting suppliers, as well as the impact of these choices on the beneficiaries, are not taken into account.

Another study provides a detailed analysis of one of the innovative technological solutions that contribute to sustainability in logistics, namely: the use of 3D printers for manufacturing spare parts needed during military missions and ensuring the sustainable supply of such goods. The study is significant because it offers a literature review dedicated to this topic, examines the specific case of the supply chain for spare parts within the Dutch military, and provides access to expert insights obtained through structured interviews. These interviews were conducted following the analysis of 40 articles and 12 scientific papers selected from a total of 78,439 publications identified on this topic ([Den Boer, Lambrechts and Krikke 2020, 1-11](#)).

Although the authors argue for the sustainable potential of this technology in preventing disruptions in the supply chain, challenges such as the high costs associated with acquiring and maintaining 3D printers, sourcing energy, and identifying local partners point to the need for further research. This is necessary to address issues such as: outsourcing the production service or providing it through military specialists, storing and transporting raw materials, information security, availability of data on product specifications, obtaining certifications for manufacturing spare parts, and respecting the intellectual property rights ([Den Boer, Lambrechts and Krikke 2020, 5-10](#)).

Since the analysed studies showed that the biggest challenges related to the implementation of AM technology are linked to the manufacturers' willingness to disclose product specifications, and considering that the authors do not advocate this solution for industrial-level production, but rather for small quantities and complex operational situations, it follows that a possible remedy could lie in how contractual clauses are formulated. This aspect could represent a possible direction for further research, as the study highlights the need for digitalisation in the field of military logistics and cooperation with manufacturers, paving the way toward the alternative of sustainable procurement in the military sector ([Den Boer, Lambrechts and Krikke 2020, 7-10](#)).

Aside from the mentioned studies, there are a few other papers within the military field which are focused on sub-elements of sustainable logistics; however, these cannot be considered relevant, as they have not been cited or used in the development of other works.

Conclusions

Considering the analysis conducted on studies from the civil domain of sustainable logistics, it can be concluded that future research should have an interdisciplinary character and should aim to maximise the potential for an integrative approach to the five identified thematic areas. At this point, two elements emerge as essential for progress in this direction: the digitalisation of logistics processes and the implementation of technologies that facilitate the transition toward sustainability. From this perspective, future research should focus on identifying the barriers (challenges) that hinder this transition. While the benefits of a sustainable approach to logistics are often emphasised, the same cannot be said about the consequences of this transformation. Therefore, future studies should address each challenge in parallel with the effects generated by the integration of sustainability.

Moreover, the results of these studies could support the aforementioned transformations within the decision-making process, enabling decision-makers to adopt informed choices that take into account both the reflection of the three dimensions of sustainable development at the logistics level and the implications of adopting appropriate technologies and the expected outcomes.

Insufficiently explored by previous studies, the social dimension of sustainable logistics must benefit from research that targets both the advantages for logistics employees and communities. One underexplored area in this regard appears to be humanitarian logistics. This thematic line also serves as a bridge between civil and military logistics, with recommendations from previous research focusing on identifying sustainable modes of operation, similar to those adopted by military structures. However, the lack of studies confirming how this is approached at the military level only reinforces the need for dedicated research in this area. Specifically, future studies could focus on identifying lessons learned from humanitarian actions involving military structures, which may have the potential to facilitate the integration of sustainability in both civil and military contexts. Additionally, less-studied aspects such as sustainable transportation, production, procurement, and storage should receive greater attention from researchers.

From the perspective of the analysed military studies, it can be considered that publications in the field of sustainable military logistics are scarce, lacking interconnection, and focusing on isolated elements drawn from the sphere of economic sustainable logistics. Addressing only two of the five thematic areas identified in the case of civil logistics (the need for the digitalization of military logistics to facilitate the integration of advanced technologies, and the use of decision-making criteria based on the three dimensions of sustainable development), research in the field of sustainable military logistics is still in its early stages. It follows that each of the activities falling under the five thematic areas addressed in civil logistics could represent a potential future research direction within military

logistics. Furthermore, to facilitate the adoption of sustainable logistics solutions, future research could focus on identifying ways to operationalise the concept of sustainable procurement in the military.

Last but not least, another conclusion drawn from the analysis of military publications is the need to define the concept of sustainable military logistics. Although the present study highlights a series of dimensions and subdimensions of this concept, mainly from the perspective of studies in the field of civil logistics, the consideration of these components in the context of military logistics must be grounded in impact studies that do not jeopardise the success of military operations.

Acknowledgements

This study includes parts of the Research Report No. 2, related to the doctoral thesis titled “*Integrated Management of Defence Resources in the Context of Sustainable Development*,” publicly defended in September 2024.

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