

СЕКЦІЯ 4.

ЕКОСОЦІАЛЬНИЙ МЕНЕДЖМЕНТ В КОНТЕКСТІ ЄВРОІНТЕГРАЦІЙНИХ ПРОЦЕСІВ / ECO-SOCIAL MANAGEMENT IN THE CONTEXT OF EUROPEAN INTEGRATION PROCESSES

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LIFE CYCLE ASSESSMENT AS A DRIVER FOR SUSTAINABLE PHARMACEUTICAL SUPPLY CHAINS

Abstract. The COVID-19 health contingency highlighted several countries' reliance on India and China to meet their medication demands, prompting them to explore alternative solutions. France's reindustrialization efforts to address medication scarcity include the relocalization of drug production. This study explores how Supply Chain Management (SCM), Life Cycle Assessment (LCA), and Social Life Cycle Assessment (S-LCA) complement each other in achieving sustainable medicine supply chains. Through a case study on paracetamol tablet manufacturing, environmental and social impacts are assessed, highlighting the importance of integrating these methodologies for informed decision-making. Results show that manufacturing in France offers a more sustainable option. This work underscores the need for further research to develop effective supply chain reconfiguration strategies and enhance sustainability.

Keywords: LCA, S-LCA, SCM, pharmaceutical supply chain, sustainability

Introduction. Offshoring manufacturing supply chains to lower-cost markets has been a logical cost-saving strategy for many companies. However, it has also increased the complexity of the pharmaceutical supply chain. This reliance on sourcing active pharmaceutical ingredients (APIs) from other nations puts Europe's entire manufacturing cycle at risk, especially during global crises and geopolitical tensions. The COVID-19 health contingency, in particular, highlighted the dependency of several countries on India and China to cover the demand for medications, prompting them to search for alternative solutions. As part of a re-industrialization plan to address medication scarcity, the French government has taken measures such as the relocalization of fifty drugs [1].

Paracetamol is an over-the-counter medicine widely used for various common diseases. Its sales were limited to two boxes per patient in 2022; additionally, in January 2023, its online sales were banned until the end of the month, and health professionals were asked to reduce paracetamol prescriptions. Several manufacturing plants are being relocalized to mitigate this scarcity, including the construction of a plant in Roussillon, France; its first delivery is estimated to take place in 2025. Manufacturing this medicine in France will contribute to meeting the demand for the drug. However, it is crucial to consider the environmental and social risks associated with changing the logistics of the supply chain.

Purpose. This study explores the synergies between SCM, LCA, and S-LCA to provide a hybrid approach for reconfiguring the Sustainable Medicine Supply Chain (SMSC). The goal is to assess the reconfiguration of the paracetamol supply chain system from an LCA perspective to reduce global climate change and offer insight into possible social impacts.

According to [2, p. 7] LCA evaluates the environmental impacts of a product or service based on a particular functional unit, considering all its life cycle stages to identify the improvements that can be made in a product's life cycle or the designing of a new product. It consists of four stages: goal and scope definition, inventory analysis, impact assessment, and interpretation. ISO 14044 (2006) states that a functional unit is the “quantified performance of a product system for use as a reference unit.” The Life Cycle Inventory (LCI) stage quantifies all the flow of materials and energy emissions that cross the system boundary. The Life Cycle Impact Assessment (LCIA) stage links the LCI information to the environmental impacts to determine the magnitude of the impacts generated by each substance. The last stage of an LCA study is the interpretation to be done iteratively through each stage of the LCA.

According to [3, p. 7], Social Life Cycle Assessment (S-LCA) is a methodology developed to assess the negative and positive social impacts of products and services throughout their life cycle. It encompasses four stages, following in general terms the same principles as LCA but focused on social stakeholders like “worker,” “local community,” and “society.” SCM is a comprehensive process that encompasses the planning, execution, and control of all the activities involved in the supply chain, starting from the procurement of raw materials through production and distribution and culminating in the delivery of the final product to the end consumer. Efficiently managing supply chains is crucial for any company looking to stay competitive and prosper, leading to lower costs, faster production cycles, and, consequently, increased profits.

The synergies between SCM, LCA, and S-LCA are several, especially in sustainable practices such as eco-social management. They offer different approaches to the same processes within a supply chain, for example, SCM focuses on the logistical and operational aspects of managing the flow of goods and services from raw material acquisition to delivery to the end consumer; LCA, on the other hand, provides a comprehensive assessment of the environmental impacts associated with a product or service throughout its life cycle; and S-LCA extends this assessment to include social impacts, such as labor conditions, human rights, and community well-being, across the supply chain.

LCA and S-LCA rely on data about producing and distributing goods and services; SCM generates this information. Within a traditional supply chain, the manufacturing plan details the various processes involved, including the flow of materials and energy. This valuable data serves as the foundation for crafting a thorough inventory at the process step which is then assessed and linked to the impact categories to determine the environmental and social hotspots in the supply chain, ultimately revealing the linkage between LCA S-LCA and SCM. Overall, SCM, LCA, and S-LCA are closely related disciplines that offer complementary supply chain perspectives as shown in (Figure 1).

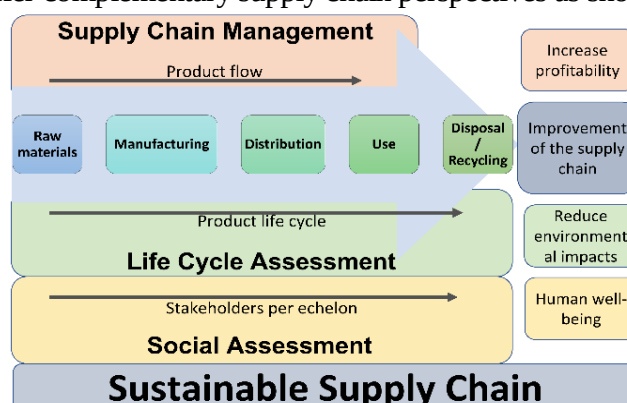


Figure 1 – The Sustainable Supply Chain

Source: Formed by authors

The goal of the LCA in this study is to carry out a comparative environmental impact assessment of the paracetamol manufacturing tablet to identify the highest contributions to global warming in two different configurations. The functional unit is one hundred thousand paracetamol tablets, equal to one batch. The system that is being modeled in the present work, as well as the production process of the pills, is presented in (Figure 2). The scope of this LCA excludes the product's use and disposal phases, the API production, and the transportation within France. It encompasses raw materials, electricity, and transportation from India to France. The life cycle impact assessment and inventory compilation were completed using the LCA software SIMAPRO 9.4.0.2 and the ecoinvent v3 database.

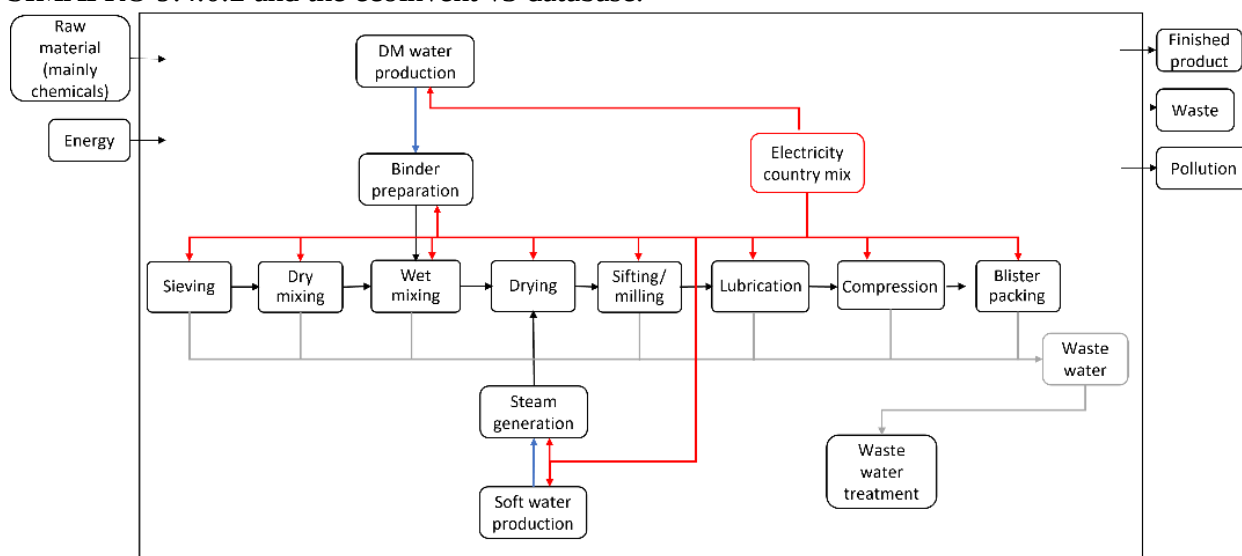


Figure 2 – System boundary for LCA

Source: Modified from [4]

LCI consists of the inputs and outputs, such as materials and energy from all the processes included in the system boundary for generating the functional unit. The production process information is based on the work of [4]. However, inventory information in the pharmaceutical industry is often scarce and confidential. The involved data sources are:

- Production process information was sourced from literature data.
- The Ecoinvent (version 3) database for emissions for each material and process.

Efforts are made to expand the system boundary proposed by [4, p. 5] incorporating additional materials that may have been excluded due to data availability. Sea freight was selected as the transportation mode from India to France given its common usage and cost-effectiveness. Country-specific inventory information, such as water and electricity mix, is selected accordingly. With these configurations for each setup, this study presents a novel approach that enhances the previous work and further enriches the analysis.

The LCIA was conducted using the 'ReCiPe' midpoint impact assessment method, and for the sake of illustration, the impact category chosen for the analysis is global warming. The two scenarios studied are the following ones: (1) manufacturing the pills in India and then transporting them to France vs. (2) manufacturing the pills in France for consumption within the country.

The S-LCA framework employs a stakeholder approach to assess potential impacts across various stakeholder categories. This study uses the stakeholders defined in the guidelines for S-LCA [5] published by the United Nations Environment Programme. The selected subcategories for the stakeholder “worker” are working hours, health and safety, and fair salary; and for the “local community”, the subcategory is local employment.

Results. This section presents the contribution to global warming for each configuration of the SCM and the social implications. As seen in (Figure 3 (a)), producing one batch of

paracetamol tablets in India and then transporting it to France results in a higher contribution to global warming, producing 64.54 kg CO₂ eq in comparison to producing it in France, which generates 26.84 kg CO₂ eq.

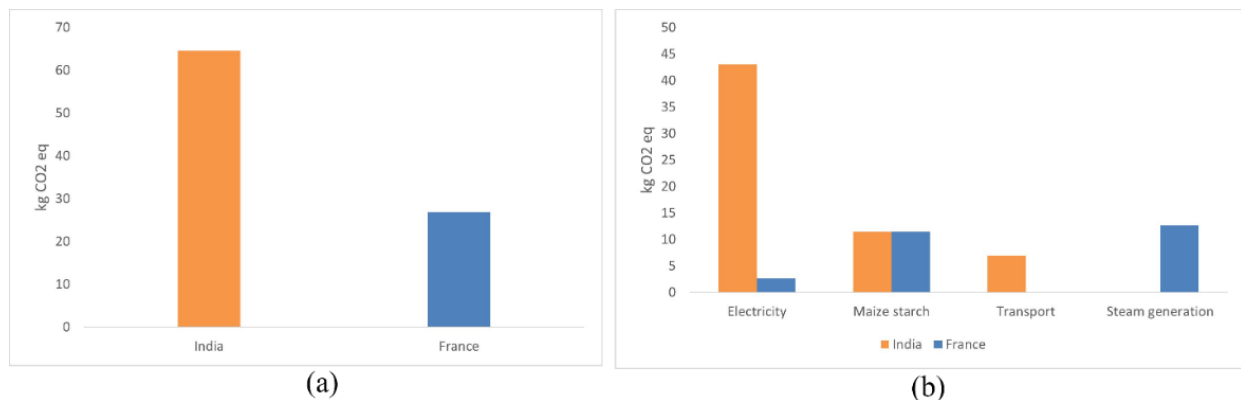


Figure 3 – Contribution to Global Warming (a) Manufacturing one batch of paracetamol tablets in two countries. (b) Processes with the highest contribution in India and France
Source: Formed by authors

The process that contributes the most to global warming is the electricity country mix, as shown in (Figure 3 (b)). In India, electricity production relies on coal thermal power plants [6, p. 10] due to the cost-effectiveness thanks to India's significant coal reserves. In contrast, electricity production in France is predominantly nuclear-based. This plays a crucial role in reducing CO₂ emissions, explaining the disparity in electricity's contribution to global warming.

Over 95 percent of ships are powered by internal combustion engines running on various petroleum products, including heavy fuel, marine gas, and marine diesel [7, p. 2]. When manufacturing in France, steam generation contributes significantly to global warming; according to this process documentation, in the EU chemical industry in 2010, the consumption of oil equivalent amounted to 53.6994 million tonnes, and it was assumed only that 40% of the energy was delivered as steam.

According to the International Labour Organization (ILOSTAT) [8], the average weekly hours worked per person in France is 35.9, with only 9% of employed individuals working 49 or more hours per week. In contrast, these indicators are higher in India, with 46.7 hours and 51%, respectively. The work-related fatalities in France and India in 2020 are 550 incidents in France [9], and 1050 in India [10]. The Purchasing Power Parity (PPP) compares the purchasing power of the countries' currencies; a fair salary implies that workers should receive equal pay for work of equal value, in this sense, the statutory gross monthly minimum wages in US dollars converted to the 2017 PPP is an indicator of fair salary. The information in [11] states that for France, the minimum wage is 2016 PPT, and for India, it is 220 PPT.

Unemployment refers to the share of the labor force that does not have a job but is seeking employment. Paradoxically, low unemployment rates can relate to poverty in a country, while high unemployment rates can occur in countries with high economic development and low poverty rates. According to [12] France had a 7.1% unemployment rate while India reported a 4.7%.

Conclusions. A hybrid approach to address the reconfiguration of the SMSC was explored. By simulating two different SMSC configurations and assessing their impact on global warming and possible social impacts, this study provides an objective foundation for informed decision-making. Results demonstrate that manufacturing paracetamol pills in France not only help alleviate the current scarcity of this medication but also offers a more sustainable option for reducing global warming. The connection between LCA and Supply Chain Management has not yet been established, decision-makers would have relied solely on economic, social, and political

factors, among others, to guide their actions, missing out on the added value that an ecological perspective can provide. The social implications of both configurations of the Sustainable Medicine Supply Chain (SMSC) encompass various socio-economic factors. In France, the lower average weekly working hours, and the proportion of individuals working long hours and fewer work-related fatalities suggest a potentially safer and more balanced work environment. Additionally, the higher PPP of France compared to India translates into higher wage levels and purchasing power, evidencing potential advantages for workers. Conversely, India's lower unemployment rate and more extensive net migration suggest different labor market dynamics.

By integrating LCA and S-LCA into SCM practices, organizations can better measure and track their sustainability performance, which includes monitoring environmental and social indicators. By quantifying these impacts, organizations can identify areas for improvement, set targets for sustainability goals, and communicate their progress to stakeholders. The combined use of these approaches leads organizations to achieve more sustainable and responsible supply chain practices that benefit the planet and society.

Although the present study examines the contribution to global warming through simulation in reconfiguring the SMSC, it acknowledges that the analysis does not encompass the entire paracetamol supply chain. Future work aims to expand the system boundary, including the API production, and perform a deeper S-LCA in addition to exploring different configurations for tablet production, such as manufacturing the tablets in France and importing the API or complete domestic production, among others. Further research in this field is crucial to develop effective and sustainable strategies for SMSC reconfiguration. Such efforts will contribute to enhancing the resilience of the medicine supply chain, reducing the environmental impact, and meeting the growing public health needs sustainably.

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