

## QUANTIFYING THE SUSTAINABILITY OF THE WINE SECTOR THROUGH LIFE CYCLE ASSESSMENT (LCA)

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**Abstract:** *At present, the economy of the Republic of Moldova is largely linear. Although there are circular initiatives, a very small share of waste and by-products is reintegrated into the economy. The new strategic framework of the Republic of Moldova provides for the increase of sustainable practices, from which can be listed: National Development Strategy "Moldova 2030", Moldova-EU Association Agreement, New Association Agenda for 2021-2027, Environment Strategy 2030. They focus on the prevention and management of waste, which is intended to drive economic growth and environmental responsibility. It's certain that the industry has a key role to play in making specific commitments on sustainable production and cooperation along value chains. In this regard, companies need to reconsider their current business models by adopting resource-efficient production. Actually, substantial amounts of resources such as secondary raw materials are transformed into waste, reaching landfills. Only the national wine industry annually generates about 60 thousand tons of by-products, most of which remain unrecovered. Therefore, this study aims to analyse the resulting waste / by-products throughout the value chain and to quantify the sustainability of the wine sector by using the LCA (Life Cycle Assessment) instrument.*

**Key words:** *sustainability, Life Cycle Assessment, environment, waste, wine sector.*

**JEL Classification:** *Q01, Q5.*

### 1. Environmental impacts of economic sectors

A major challenge facing humanity in the 21<sup>st</sup> century is climate change, which undermines the ability of all countries to achieve sustainable development and achieve the Millennium Development Goals. The Republic of Moldova is committed to achieving these objectives through the legislative framework, including: National Development Strategy (NDS) "Moldova 2030", Strategic International Commitments: Association Agreement with the European Union and the 2030 Agenda for Sustainable Development, Environmental Strategy for 2014-2023, the Energy Strategy of R.M 2030 and others. The 2030 Agenda for Sustainable Development is very complex, comprising 17 general objectives and 169 concrete objectives, covering areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice. The SDGs are interconnected, so the full mobilization of all sectors, the community, is crucial. What is certain is that full awareness and commitments are needed at several levels, which would involve central coordination at the Government level, the involvement of all public authorities, but also the private sector and NGOs.

It is gratifying that in recent years the awareness of business sustainability has increased, more and more companies are producing more efficiently, have sustainable waste management and, in general, implement activities in line with the principles of environmental protection. The 12<sup>th</sup> SDG Sustainable Development Goal addresses this issue, referring to sustainable consumption and production, which involves strengthening the scientific and technological capacity to apply sustainable, circular production and consumption models through prevention, reduction, recycling and reuse. On the one hand, these initiatives can generate opportunities for economic transformation, providing greater sustainability, and on the other hand, the ecological footprint will be reduced.

Wine sector and its impact on the environment through Life Cycle Assessment (LCA). According to Kramer et al., (1999), food production is one of the most

environmentally harmful activities, accounting for 15-20% of the world's total energy consumption.

Moreover, the report "Circular Economy and Environmental Priorities for Business" developed by the members of ECOFYS at the request of the European Commission, includes detailed information on the impact of economic sectors on the environment.

It should be noted that a significant impact is on the food, beverage and tobacco production sector, which generates 18% of the total amount of waste, emits 16% of the total greenhouse gas emissions into the atmosphere, consumes 28% of water resources and uses 20% of land resources.

**Table 1. Economic sectors and their impact on the environment**

<b>Economic sectors</b>	<b>Greenhouse gas emissions</b>	<b>Water consumption</b>	<b>Land use</b>
Agriculture, hunting, forestry and fishing	9%	37%	35%
Mining	0%	0%	1%
Production of food, beverages, tobacco	16%	28%	20%
Textiles, leather and clothing	2%	2%	2%
Wood, paper	0%	0%	3%
Petroleum, chemicals and non-metallic minerals	4%	2%	3%
Transport	1%	1%	1%
Services sector	15%	18%	17%
Electricity, gas and water	1%	1%	1%
Construction	36%	5%	9%
Manufacturing of metals, machinery, wiring	17%	5%	8%
<b>TOTAL</b>	<b>100 %</b>	<b>100 %</b>	<b>100 %</b>

Source: elaborated by source (Ecofys, 2017, p.21)

### **The environment impact of wine sector**

The food, beverage and tobacco production sector includes the wine industry, which accounts for a substantial part of this waste. Even if at first sight it would seem that wine production is a "friendly" process with nature, at a more detailed analysis, we notice its connection with other industries (glass production, transportation, energy production) that have a negative global impact on the environment. Therefore, the wine industry contributes to many global environmental problems such as global warming, ozone depletion, environmental pollution, soil degradation etc.

Numerous studies show that the production of wine results in waste of 1.3-1.5 kg per 1 liter of wine produced, of which 75% is wastewater and 25% are by-products, CO<sub>2</sub> greenhouse gas emissions, organic compounds volatile, inorganic wastes such as clay, bentonite and perlite. It should be noted that in Europe the amount of waste from wine production amounts to over 4.5 million tons per year (Sergi Maicas et al., 2020, p.3).

Globally, the wine sector accounts for around 0.3% of annual global greenhouse gas emissions, and the water footprint of wine production varies between 0.5 and 20 liters per liter of wine (Gianni et al., 2015).

Production and non-recovery of residues and by-products such as pomace, seeds, bunches, yeasts, etc. is currently a major problem for the environment, causing on the one

hand the loss of materials and energy, and on the other hand - negative effects on nature, health and quality of life. Therefore, their reintroduction into the food technology circuit must be one of the main objectives of a sustainable wine industry.

For these reasons, it is very important to evaluate wine production in terms of sustainable development. Such an assessment is crucial as in the not too distant future, sustainability will also become a mandatory requirement for producers, distributors and importers. It is certain that economic growth remains a priority, but this growth must be sustainable.

In this respect, the industry has a key role to play in making specific commitments on sustainable supply and cooperation along the value chains. The first step is a common awareness of the need for the transition and implementation of sustainable, circular business models that would reduce the environmental footprint. According to the European Commission, circularity is an essential part of a broader transformation of the industry in the transition to climate neutrality and long-term competitiveness, thus generating substantial savings in all value chains and production processes.

Therefore, this study aims to illustrate the impact of wine production on the environment through Life Cycle Assessment (LCA), starting with viticulture, vinification and bottling, packaging manufacturing, and ending with domestic and international distribution.

## 2. Life Cycle Assessment in the wine sector

According to ISO 14040: 2006, "life cycle assessment" is defined as: "a technique for determining the potential environmental impact associated with a product, service or process by assessing inputs and outputs throughout the life cycle" ( ISO 14040: 2006).

In other words, the LCA tool examines the impact of manufacturing a product/service from raw material extraction, manufacturing and consumption to the end of its life cycle - either disposal or recycling. Most studies assess the impact of wine production on the environment using the LCA environmental management technique based on 4 impact categories: carbon footprint (CF), abiotic depletion (AD), acidification potential (AP) and eutrophication potential (EP) (Ferrara and Giovanni, 2018, p.6).

**Table 2. Environmental impact indicators**

Environmental Impact	Unit of Measure	Description
Carbon footprint (CF)	Kg CO <sub>2</sub> eq.	Greenhouse gas emissions from production and consumption, which condition global warming.
Abiotic depletion (AD)	Kg Sb eq.	Depletion of the total supply of abiotic resources including water, air, land, heavy metals, minerals, etc.
Acidification potential (AP)	Kg. eq. SO <sub>2</sub>	Loss of the ability to neutralize soil and water as a result of sulphur and nitrogen oxides discharged into the atmosphere, which return to the surface as acids.
Eutrophication potential (EP)	Kg. eq. de NO <sub>3</sub>	Excessive growth of algae population due to artificial enrichment of river water and reservoirs due to the massive use of fertilizers and detergents. This generates a high oxygen consumption of the water.

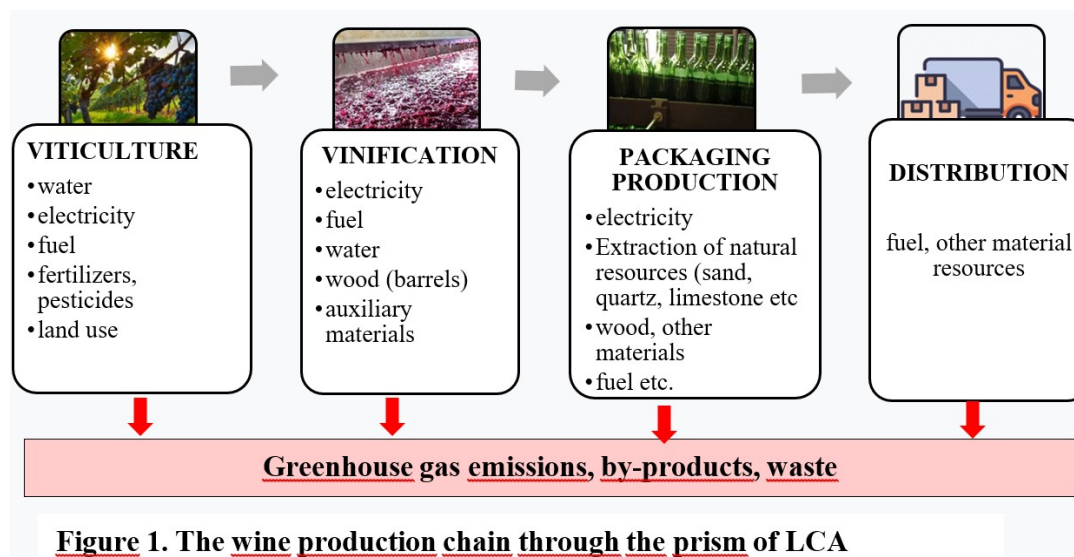
Source: Fernández et al., 2017; Wiedmann et al., 2007; Van Oers et al., 2016.

This study mainly examines the carbon footprint of wine production in distinct phases. Through the LCA perspective, the wine production chain can be divided into 4 phases: viticulture, vinification, packaging manufacturing and distribution. Each main phase of wine consists of several stages, the inputs (chemicals, energy, water, fuel, raw materials, infrastructure, etc.) and outputs (by-products, emissions, waste, etc.) must be

taken into account. Fig. 1 illustrates the main “inputs” of resources and outputs in the form of emissions, waste, by-products.

According to research on the estimation of the carbon footprint of wine production, carried out by one of the most experienced companies in terms of sustainability, can be notated that the biggest impact has the phase "Manufacture of packaging", where the production and use of glass causes 29 % of total greenhouse gas emissions, followed by the production of cardboard boxes - 6%, and other packaging materials (corks, capsules, labels, etc.) - 3% (see fig.2). What is certain is that some inputs to wine production can have a significant or non-essential impact on the environment. Among those with a major impact on the environment can be listed: fuel, electricity, inorganic fertilizers, pesticides, copper-containing substances, glass containers, corks, metal, capsules, cardboard boxes.

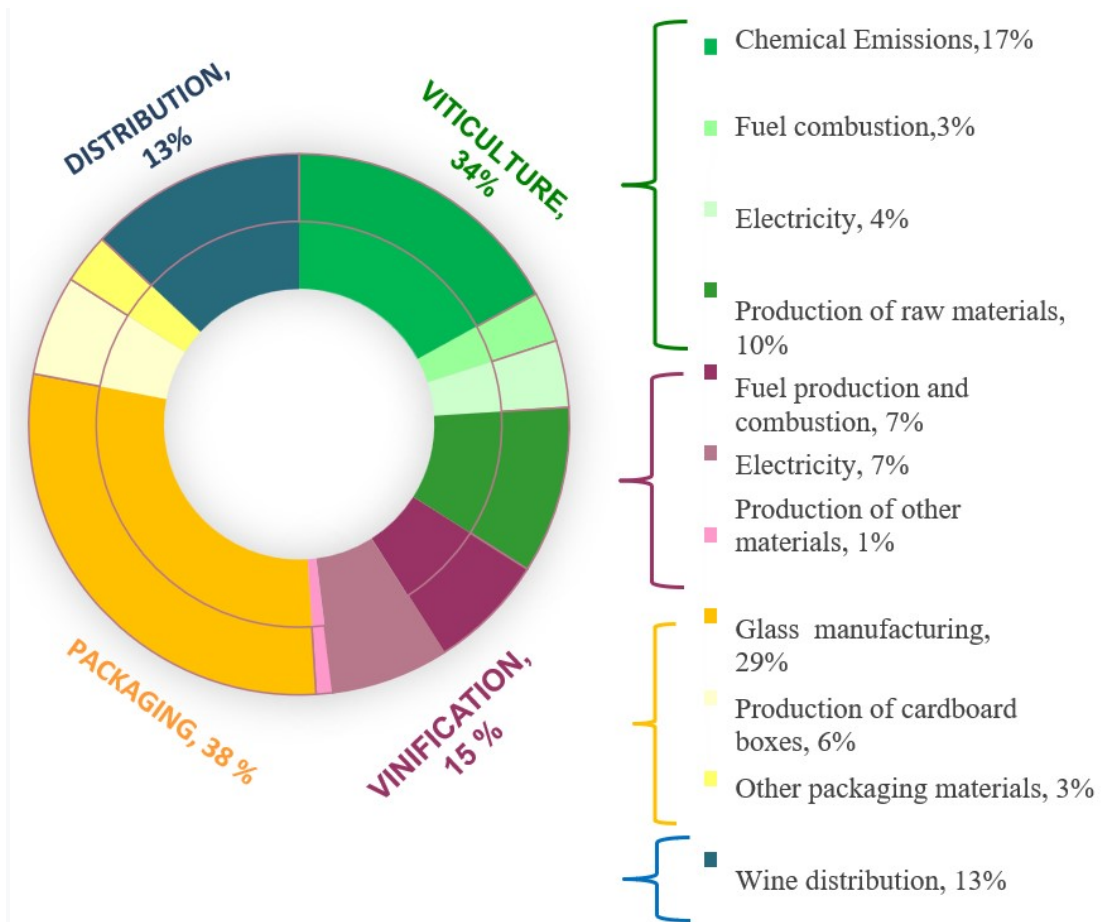
It should be noted that from the point of view of the carbon footprint, the use of cork stoppers in winemaking seems to be a "correct" practice, although we cannot say the same thing if we look at it from the perspective of the water footprint. Consequently, numerous studies identify a significant impact of cork production and use on marine depletion and ecotoxicity.



Glass packaging and cardboard boxes have the biggest impact on the environment. For every liter of wine, wineries use on average over 650 grams of glass and 50 grams of cardboard. "Packaging manufacturing" is followed by "Viticulture" being responsible for 34% of total greenhouse gas emissions, of which the production of chemicals, pesticides, fertilizers is in the first place (17%). Greenhouse gas emissions from vineyards are largely caused by emissions of nitrous oxide (N<sub>2</sub>O) released from the soil by the application of nitrogen-containing fertilizers (Gianni et al., 2015).

In "Vinification" the largest contribution on the carbon footprint can be attributed to the energy resources (electricity, diesel, fossil fuels) required in the wine production process, having a cumulative impact of 15%.

The fourth distinct phase of the production chain - "Distribution" causes 13% of the carbon footprint of the wine, mostly from the burning of fuel.



**Figure 2. The carbon footprint of wine production**

Source: elaborated by source (In International, 2011)

According to the above, the impact of wine production on the environment is significant. So, the wine industry must update its performance values taking into account the principles of sustainable development. The producer, distributor, consumer must behave rationally, conscientiously, thus reducing the environmental impact.

A sustainable practice that would reduce the carbon footprint is the use of low CO<sub>2</sub> packaging. Studies have shown that the packaging with the least environmental impact is canned wines and bottled wines.

**CO<sub>2</sub> emissions by type of packaging (Alko, 2018):**

- Traditional glass 0.75 L - 675 g CO<sub>2</sub>e per liter
- Lightweight glass bottle 0.75 L - 525 g CO<sub>2</sub>e per liter
- Plastic container 0.75 L - 245 g CO<sub>2</sub>e per liter
- 0.33 L aluminium can - 190 g CO<sub>2</sub>e per liter
- Wine in a bag 1.5 L - 96 g CO<sub>2</sub>e per liter
- 1 L cardboard box - 85 g CO<sub>2</sub>e per liter

Certainly, small sustainable changes to the traditional business model at the enterprise level can have a major impact on the environmental footprint of the industry as a whole, if they are to be considered by most manufacturers. Only the replacement of traditional glass packaging with lightweight glass bottles at the country level (Republic of Moldova) would condition the reduction of CO<sub>2</sub> emissions by more than 20%, in absolute terms by more than 7000 t CO<sub>2</sub>.

### 3. Conclusions

Sustainability in the wine sector refers to the conservation of the environment, the reduction of water and energy consumption, the recovery of by-products and the efficient management of waste. In order to preserve and use natural capital rationally, the whole life-cycle resource system must be addressed, including production methods, demand patterns, supply chains, waste management and the possibility of capitalizing on them.

The life cycle assessment (LCA) of wine production has outlined the major impact on the environment through significant CO<sub>2</sub> emissions, high water consumption, energy, soil. Most studies highlight 2 major stages with the highest CO<sub>2</sub> emissions in the wine production process - the production of glass packaging and the production / use of chemicals, pesticides, fertilizers at the stage of establishment and maintenance of vineyards.

Unfortunately, at present, globally, glass is the most common material used in wine packaging. This practice needs to be urgently improved by moving to more sustainable, more environmentally friendly packaging.

Therefore, in order to conserve natural capital and identify sustainable solutions, a joint effort is needed at all levels, both on the part of the producer, distributor, consumer and key players to identify strategies and find the right path to conservation. the resources of our planet.

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