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Transitioning the agri-food system. Does proximity mean sustainability? The social and environmental impact of production and shipping strategies. A comparison between citrus fruit productions in Spain, South Africa and the USA.

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Abstract

Agricultural techniques and orchard management play an important role in food production sustainability and there is an increasing number of research papers which focus on food cradle-to-gate life cycle assessment. In addition, there is also an emerging body of research on short food supply chains and on whether or not proximity can be a proxy for sustainability in the agri-food system. The objective of this analysis is to consider the most relevant social and environmental impacts of the Environmental Footprint and Social Life Cycle Assessment in the citrus fruit sector and identify crucial hotspots. We will explore the relevance of the length of citrus fruit supply chains on maps of social and environmental impacts in order to reach more wiser sustainability-based decisions. The results obtained show mixed conclusions regarding the relevance and implications of choosing short food supply chains to achieve more sustainable food systems.

Keywords

Sustainable food system, Short supply chains, Environmental footprint, Social life cycle assessment, Global supply chains, citrus

Introduction

The global population is expected to increase from roughly 7.7 billion to nearly 10 billion by 2050 (Would Economic Forum, 2020). Moreover, current global agri-food systems are highly unsustainable, which creates environmental (Beccali et al., 2009) and socio-economic problems (Tecco et al., 2016). In the last five decades, agriculture and food production, ruit production especially, have been gradually transformed into highly specialized activities which focus on increased production with quality characteristics that satisfy the demands from globalized markets (Cavallo and Marino, 2014). This has dramatically modified farm-to-fork supply chains by transforming production, packaging, and marketing activities and by breaking links with their territorial origins. It is in this context where these agri-food systems face key challenges transitioning to more sustainable systems that better address sustainability issues such as climate change, water, and land resource use. Resources that ensure steady food provision are becoming scarce and so is the capacity to empower and maintain social welfare along supply chains ~~actor~~ since social welfare has diminished along the entire product life cycle.

For that aim, monitoring sustainability impacts along the whole supply chains of food products, not only inside organizations but beyond their boundaries, is crucial. Seuring and Müller (2008) provided a clear definition of sustainable supply chain management (SSCM) as *'the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements'.* These dimensions of sustainable development are key to assessing sustainability along different citrus fruit supply chains, regardless of their length or their complexity.

Moreover, short food supply chains are gaining momentum and are being directly associated with better product quality or more sustainable production and commercial practices; yet, production location does not ensure quality and safety, nor that the products have a low environmental impact or include social responsibility attributes (Winter, 2003; Aubry and Kebir, 2013). A sustainability-oriented decision based on the origin of a food product might avoid social and/or environmental inefficiencies hidden behind the impact of only one life cycle phase; i.e. the transportation phase, on sustainability assessment, the transportation phase.

To meet most of these challenges, within the so-called traditional or mainstream agri-food systems (for example, citrus fruit production in Spain that can be labeled as "ecological" is only around 5%), it is necessary to consider how the agri-food system has contributed to sustainable development and how to measure and assess its social and environmental impacts. Life cycle assessment (LCA) is one of the most common and comprehensive tools to compare environmental burdens arising from the agri-food sector (McAuliffe et al., 2020). To address the social impacts of the system along the whole supply chain, a social life cycle assessment (S-LCA) should be applied.

As Bubicz et al. (2019) state, supply chains need to be reviewed from a holistic systems perspective, going beyond a single activity (such as production). Moreover, according to the authors, little is known about the social dimension of sustainability across the supply chain. In 2013, the European Commission (EC) published a recommendation on the use of a common methodology to measure and communicate the environmental performance of products and organizations (EC 2013); the core of the this methodology is life cycle assessment (LCA). Since then there has been a growing body of research to assess the impacts of agri-food production. However, the environmental and economic perspectives have been dominant in sustainable supply chain management studies and the social dimension has not been properly dealt with. Social sustainability within supply chain management can be associated with the assessment of processes and products so as to identify socio-economic conditions of the people who participate in the supply chains (Mani et al, 2016; D'Eusanio et al., 2019). In addition, in agricultural systems, a more holistic approach to sustainability should be taken, in which both, environmental and social dimensions and their interactions are taken into consideration (Vermunt et al., 2020). Thus, this paper seeks to contribute to the supply chain and social sustainability literature by providing empirical evidence on the social hotspots of citrus fruit supply chains.

In this context, the research question that arises is:

Is proximity of food production to markets a good proxy indicator for market actors to make more sustainable decisions? or do they need to deepen in the supply chain behavior to make informed decisions?

To answer this question, this paper will analyze the environmental and social hotspots of a citrus fruit product along its whole supply chain. We will focus on the origin of this food product and its proximity to the market, a key factor in exploring its sustainability implications and, consequently, the relevance of the length of citrus fruit supply chains on its social and environmental impacts map. Figure 1 summarizes the rationale of this research based on Dyllick and Muff's (2016) 'input-process-output' proposed model.

This research has adopted a cross-country perspective of the social and environmental impacts of citrus fruit production and commercialization, through the analysis of the contribution of different market strategies (proximity versus long-distance markets) to a more sustainable agri-food system, using social and environmental LCA. To shed light on this, analytical research will be undertaken based on impact assessment and social and environmental LCA in three different scenarios of the production-transport-final market (Orchard/Farm-to-Fork).

Figure 1. Input-Process-Output Research definition

What?	*How?*	*What for?*
To study the relevance of the length of a citrus fruit product supply chain on its social and environmental impacts map	By analyzing the environmental and social hotspots of a citrus fruit product along its whole supply chain, focusing on the origin of this food product and its proximity to the market, as a differential factor. Tool: Social and environmental LCA in three different scenarios (cross-country perspective) of the production-transport-final market. Product: citrus fruits (orange)	To come to more sensible sustainability-based decisions in food systems.

This study aims to address the following research questions: how consistent market actors' decisions based on proximity or short supply chains are and how holistic the concept of sustainability is, where complexity and multiple impacts should be taken into account when selecting suppliers in purchasing decision-taking. This stresses the importance companies should place on examining their impacts along supply chains. A product made or a service provided by an organization with inputs from other organizations that are not operating sustainably cannot be sustainably produced. Environmental and social footprints may serve as indicators of how human activities which produce goods or services may impact the environment or social wellbeing. The quantification of footprints, which is based on life cycle thinking along the whole supply chain, seeks to produce a complete image of the real pressure of a product or an organization over the environment or society.

The objective of this paper is to carry out an analysis of the social and environmental impacts of the citrus fruit supply chain and to outline the farm-to-fork (orchard-to fork) fruit market strategy. We will therefore perform desk research to assess the social and environmental impacts along the product life cycle in order to, on the one hand, fully explore, the citrus fruit production hotspots with a cross-country perspective by using environmental and social footprints to assess organizational impacts; and, on the other hand, to have a clearer picture on how different managerial strategies, like selling or purchasing decisions, can create different social and environmental sustainability impacts. We will focus on the orange case study, as this fruit tops the list of one of the most consumed fruits, not only in fresh but also in juice.

To our knowledge, there are not many papers that focus on a cross-country comparison on sustainability impact assessment for the same crops. Pretty et al. (2014) performed an analysis from Unilever's perspective of selected sustainability indicators (not LCA) for five typologies of crops produced in 11 countries, which is the only piece of research which lends this holistic and life-cycle perspective to the citrus fruit sector.

The remaining part of the paper proceeds as follows: section 2 analyzes the state-of-the-art in sustainability along the citrus fruit supply chain and how to assess it. This section presents a literature review of environmental and social life cycle assessment methodologies and results in citrus fruit and of the supply chain length and transport impact. Section 3 deals with research design, materials and methods and provides a description of the European Organization Environmental Footprint and the social footprint, which will offer the framework of reference for this paper. Section 4 shows the main results obtained and Section 5 includes a discussion of the implication of these results. Finally, conclusions of this research are drawn.

1. The state-of-the-art in citrus fruit Social and environmental life cycle assessment.

To support the agri-food system transition to a more sustainable farm-to-fork strategy, this research will analyze the suitability of social and environmental life cycle assessment methodology, which plays a key part in how market actors participate in the decision-making process in terms of sustainability. The paper will examine the extent to which some variables, like proximity of agri-food production to consumers, could be used as a good proxy to make decisions or, if necessary, to use an extended set of variables to secure sustainable food production and consumption.

As Heller et al. (2017) state, there are some important research gaps in how environmental impacts differ among different citrus fruit producing regions across the world. Moreover, it is unclear whether these differences are real or due to methodological differences. This gap is even bigger in terms of social impacts of fruit production and post-harvest handling as, to our knowledge, there is no public information, nor research results about the social impacts of crop production and handling across the most important producing regions.

Furthermore, an important question about transport impact along global supply chains remains unanswered as well as whether or not shortening supply chains may improve sustainability. There is some research (Knudsen et al., 2011) on freight mode and distribution channels in GHGE and acidification potential of citrus fruit and frozen concentrated juice.

Short food supply chains are alternative agri-food systems that include different forms of distribution characterized mainly by few, or no, intermediaries between consumers and producers, or short geographical distances between them (Deverre and Lamine, 2010; Parker, 2005). Some authors have developed typologies keyed to the maximum number of intermediaries or the nature of the social relations established in the production chain (Aubry and Kebir, 2013). However, for the scope of this research, the strategy pursued is the geographical closeness of food producers to consumers. Shortening the agri-food chain is being presented in many commercial schemes as a synonym of sustainability and also healthy products. In this sense, although short food supply chains are associated with better product quality, social supportive production and fair commercial practices, these characteristics do not develop automatically. Proximity alone does not ensure product quality nor food safety; environmental and social impacts created by products made by competitors cannot be lessened either. In fact, Winter (2003) argues that *"the turn to quality has no single defining set of characteristics based around local ecologies. On the contrary, there are different and contrasting strands of quality consumerism with many contradictions and tensions between them"*. Therefore, sustainability should be one of the possible quality attributes and the different environmental and social impact categories that the sustainability concept includes and should be assessed in a holistic way to support informed business-to-business or consumer decisions. Moreover, for the agri-food sector, with global chains of suppliers frequently operating in low-income and low labor cost countries, the high social impacts arising from production and manipulating processes, put suppliers in the spotlight for the achievement of sustainable development.

Regarding citrus fruit life cycle assessment studies, and for initial screening, the method used to search the relevant literature involved using Web of Science and Scopus databases and different search strings were pulled in July 2020. The criteria to be included are peer-reviewed journal articles written in English:

- Scopus search for "citrus fruit" and "life cycle": 48 papers that have been reduced to 9 after refining the search with "assessment" and reading the abstracts to focus on footprint methodologies.
- Snowball effect with documents cited by the previously 9 selected documents, refined the search with" "citrus" and "environmental footprint": 12 papers.
- Scopus search for "Social life cycle assessment" and "fruit": 5 papers.
- WoS search for: "life cycle assessment" and "fruit", refined with "citrus": 34 papers.
- WoS search for "Social Life cycle assessment" and "fruit": 4 papers.

Using these search criteria, and after eliminating duplicities, 53 papers were categorized as studies focused on environmental and social LCA of citrus fruit production and processing. After reading the abstracts carefully, the 53 papers were reduced to 40. Although some of these papers (7 papers) do not fully focus on citrus fruit, we have kept them on a extended list[1], as they provide interesting insights on fruit LCA and

[1] Extended list is available upon request to authors.

comparative LCA methodologies or because they deal with Social LCA, where research is scarce.

Table 1: Literature review of citrus fruit environmental and social LCA

Scope	*No. of studies*	*Country*	*System boundaries*	*Products*	*Authors*
Carbon Footprint	6	2 Spain 2 US China Multi-Country	4 cradle-to-gate 2 cradle-to-market	2 Multifruit, 6 Oranges, 1 Clementines	Aguilera, Guzman & Alonso (2015); Bell & Horvath (2020); Blanke (2014); Dwivedi, Spreen & Goodrich-Schneider (2012); Ribal, Estruch, Clemente, Loreto-Fenollosa & Sanjuan (2019); Yan, Cheng, Yue, Yan, Rees & Pan (2016)
Environmental LCA	17	6 Italy 2 Italy + Spain 2 Spain 1 Colombia 1 Iran 1 UK 1 Indonesia + Morocco 1 France + Morocco 3 Multi-country	10 cradle-to-gate 7 cradle-to-market	5 Multifruit, 5 Oranges, 1 Clementines, 5 Lemons, 1Bergamot, 1 Taroco 2 Orange juice	Alishah, Motevali, Tabatabaeekoloor &Hashemi (2019); Basset-Mens, Vanniere, Grasselly, Heitz, Braun, Payen, Koch, & Biard (2016); Beccali, Cellura, Iudicello & Mistretta (2010); Beccali, Cellura, Iudicello & Mistretta (2009); Bessou, Basset-Mens, Latunussa, Velu, Heitz, Vanniere & Caliman (2016); Bessou, Basset-Mens, Tran & Benoist (2013); Frankowska, Jeswani & Azapagic, (2019); Lo Giudice, Mbohwa, Clasadonte & Ingrao (2013); Martin-Gorriz, Gallego-Elvira, Martínez-Alvarez & Maestre-Valero (2020); Miranda-Ackerman, Azzaro-Pantel & Aguilar-Lasserre (2017); Nicolo, De Salvo, Ramirez-Sanz, Estruch, Sanjuan, Falcone, & Strano(2015); Nicolo, De Salvo, Ramirez-Sanz, Estruch, Sanjuan, Falcone, & Strano (2018); Pergola, D'Amico, Celano, Palese, Scuderi, Di Vita, Pappalardo & Inglese (2013); Ribal, Sanjuan, Clemente & Loreto-Fenollosa (2009); Sgroi, Candela, Di Trapani, Fodera, Squatrito, Testa & Tudisca (2015); Strano, Falcone, Nicolo, Stillitano, De Luca, Nesci & Gulisano (2017); Tyszler, Kramer & Blonk (2014)
LCEnergyA	1	Italy	cradle-to-gate	Clementine	Falcone, Stillitano, De Luca, Di Vita, Iofrida, Strano, Gulisano, Pecorino & D'Amico (2020)
Waste valorization	5	1 Italy 1 Spain 1 UK 1 Colombia 1 -	Market-to-grave	3 Orange peels 2 Multifruit	Garcia-Garcia, Stone & Rahimifard (2019); Joglekar, Pathak, Mandavgane & Kulkarni (2019); Martinez-Hernandez., Magdaleno-Molina, Melgarejo-Flores, Palmerín-Ruiz., Zermeño-EguiaLis, Rosas-Molina, Aburto & Amezcua-Allieri (2019) Negro, Ruggeri, Fino & Tonini (2017); Ortiz, Batuecas, Orrego, Rodríguez, Camelin & Fino (2020)

Social LCA	4	2 Italy 1 Canada 1 Multi-country	cradle-to-gate	1 Oranges 3 Multifruit	Andrews, Lesage, Benoît, Parent, Norris, & Revéret (2009); De Luca, Iofrida, Strano, Falcone & Gulisano (2015); Macombe, Loeillet & Gillet (2018) Iofrida, N., De Luca, A. I., Silveri, F., Falcone, G., Stillitano, T., Gulisano, G., & Strano, A. (2019)

Source: Own creation using WoS and Scopus Databases. Accessed July 2020

Table 1 presents the results of the systematic review of the 33 research results that focus on citrus fruit sector impact assessment with a clear life cycle thinking perspective. We have categorized the studies taking into account LCA objectives, geographical scope, system boundaries and product consumption (fresh or processed into juices and other byproducts). Besides, we have identified five studies on citrus LCA, predominately at the environmental level, from grey literature; these papers focus on different citrus fruit LCA from cradle-to-gate in Spain and Italy. This categorization of previous research has helped us not only to have a more comprehensive overview of this research area but also to delve into the key life-cycle phases that have been under study. Moreover, this literature review also shows the current state-of-the-art regarding sustainability assessment methodologies in the citrus fruit sector.

Most of the papers have a clear technical perspective, i.e. to provide insights about the different environmental impact categories along the supply chain. These papers give an in-depth analysis of the different production phases and show how to perform and quantify a LCA using raw data from orchard to gate. The main objective is to carry out an environmental hotspots analysis together with the production and handling of different citrus fruit varieties. In addition, there is a subgroup of papers which deal with carbon footprint assessment and the possibility of using citrus fruit orchards as carbon capture schemes.

There is a second body of research that covers the last part of the life cycle of these products connected with waste and byproducts valorization. In this group of papers, research is based on how to reduce and valorize food losses from supermarkets and how to give a commercial possibility to citrus waste.

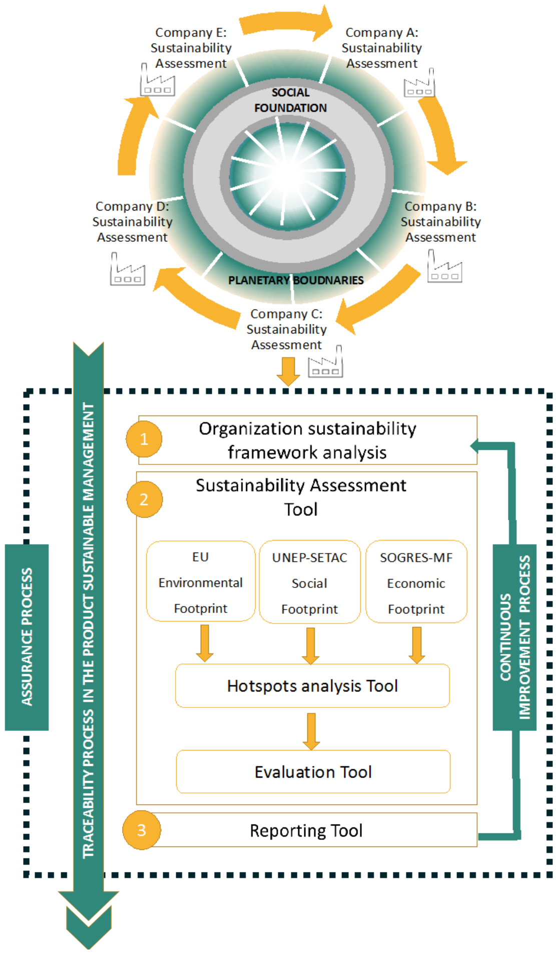
Regarding social sustainability along citrus fruit supply chains, which is operationalized by using SLCA, only two papers (De Luca et al., 2015; Iofrida et al., 2019) look at the social assessment of citrus fruit production. These two papers analyze the impact categories concerning working conditions and workers' health, which have received the greatest attention and have been the most frequently analyzed and evaluated topics in SLCA literature. De Luca's paper was conducted to test the suitability of SLCA from cradle-to-farm gate, which established a connection with other methodologies such as characterization using a Social Impact Matrix (SIM) and normalization and weighting using AHP, with pairwise comparison and stakeholders' priorities. Iofrida et al. (2019), based on Gasnier (2012) and Silveri (2014) social impacts on workers of psychosocial risks, examine the impacts on the labor force; without considering a more extensive catalog on impact assessment categories, like impacts over society, local community, consumers or other value-chain actors.

Although there is no consensus about how the sustainability performance of supply chains can be measured, the literature review shows that most articles focus their empirical analysis on life cycle assessment methodologies by presenting different tools to measure and account for the environmental and social impacts on the supply chain.

2. Materials and Methods

This study is based on the SMART Sustainability Assessment Guide, the methodological framework described in Muñoz-Torres et al., (2018, 2019). This assessment framework provides, on the one hand, an integrative solution for explaining sustainability principles when analyzing business operations; and, on the other hand, it contains science-based tools for analyzing the extent to which companies are operating sustainably. This framework offers, as pictured in Figure 2, different steps and tools.

Figure 2: Sustainability Assessment Framework



Source: Muñoz-Torres et al. (2019)

For the purposes of this research, and to offer a technical assessment of the social and environmental impacts that are created along the citrus fruits supply chains, we will focus on step 2: the sustainability assessment tool and its first phase, footprints tools. The framework relies on footprint methodologies to identify and measure environmental and social impacts: the Organization Environmental Footprint from the European Commission (2013) and the UNEP/SETAC (2009) methodology; tools which promote best practices and align efforts with key initiatives. Social and environmental sustainability in the supply chain entails that every actor along the supply chain network needs to be aware of their 'contribution' to the main social and environmental impacts of their products, downstream and upstream, inside and outside the chain, and that practices are introduced so as to address those impacts. Hence the need to identify and assess the most relevant social and environmental impacts of the product which go beyond organizational boundaries.

The Product and Organization Environmental Footprint (PEF/OEF) (European Commission, 2013) focuses on measuring environmental impacts at the organizational and product level and on providing a holistic view on the traditional use of LCA of products over its entire life cycle (Neppach et al., 2017). The European Commission is formulating the OEF method based on life cycle-oriented methods, which seek to identify environmental hotspots, to use benchmarking, to improve business-to-business (B2B) relationships and, mainly, to develop a common methodology for measuring corporate environmental performance beyond organizational boundaries. This method assesses the environmental impacts that could occur in downstream and upstream processes along the whole supply chain.

This common method for measuring the environmental performance of products involves defining specific categories of environmental impacts at the organizational level, which include resource use or emissions of environmentally damaging substances that may affect human health. More concretely, the sixteen environmental footprint impact categories for EF studies are (European Commission, 2013): Climate Change, Ozone Depletion, Ionizing Radiation, Photochemical Ozone Formation, Particulate Matter, Human Toxicity-Non-Cancer Effects, Human Toxicity-Cancer Effects, Acidification, Eutrophication- Fresh Water, Eutrophication- Marine, Eutrophication-Terrestrial, Ecotoxicity-Fresh Water, Land Use, Water Use, Resource Use- Fossils, and Resource Use- Mineral and Metals.

At present, the EF tool is at a development stage due to its complexity and it is being tested in several pilot cases to offer a more comprehensive definition of Organization/Product Environmental Footprint Sector Rules, which could meet the specifications of certain sector requirements (Table 2). Despite this, the EF is currently considered to be a robust method for corporate environmental performance measurement and reporting (Pelletier et al., 2015). For this reason, we regard EF as a frame of reference for the identification and management of citrus fruit environmental hotspots along global supply chains. Moreover, it is consistent with the ecological system defined by the main international frameworks for institutions to address global environmental challenges, i.e., COP21, SDGs, or Planetary Boundaries (Muñoz-Torres et al., 2021).

Table 2: Comparing ILCD2011 and European Footprint calculation methods.

Impact Category	***ILCD 2011***	***EF***
Climate change	IPCC 2007	IPCC 2013 + adaptations
Ozone depletion	WMO 1999	WMO 2014 + integrations
Toxicities	USEtox™	USEtox™ (2.1)
Respiratory inorganics	(Rosenbaum et al, 2008; Greco et al, 2007; Rabl and Spadaro, 2004) Combined as proposed in Humbert (2009)	Fankte et al, 2016
Ionizing radiation	=	=
Photochemical ozone formation	=	=
Acidification	=	=
Eutrophication	=	=
Land use	SOM (Mila I Canals, 2007)	LANCA (Bos et al, 2016)
Resource use: *-Abiotic resource depletion* *-Minerals and metals resource depletion* *-Energy carriers*	 = Reserve base -	 = Ultimate reserves Considered separately
Water scarcity	Swiss Ecoscarcity 2006 (Frischknetcht et al, 2008)	AWARE (Boulay et al, 2016 UNEP, 2016)

Source: Adapted from Fazio et al. (2018)

Social Life Cycle Assessment (SLCA) is the most widely applied method used in case studies which aims at assessing social impacts (Bonilla-Alicea and Fu, 2019). According to the review carried out by Huarachi et al. (2020), there is still a long way ahead to achieve a real standardization in Social Life Cycle Assessment methodologies. In this sense, the authors highlight the significant role that the Guidelines for SLCA of products (UNEP-SETAC, 2009), the Methodological Sheets for Subcategories developed under this framework (UNEP-SETAC, 2013), and the Social Hotspots Database (SHDB) perform. In order to implement SLCA analyses and standardize SLCA, these methodologies have been employed for identifying social hotspots at sectoral level (Benoît-Norris et al., 2012) (Not clear whether the underlined sentence referred to the methods mentioned in the previous sentence or just the SHDB).

Regarding the analysis on *what social issues* SLCA should include, table 3 shows the social impact categories (themes) that the SHDB establishes (Benoit et al., 2015).

Table 3: Social Impact Categories on SLCA using SHDB databases

Social Category	***Impact Categories (Subcategories)***
Labor rights and decent work	Child Labor, Forced Labor, Excessive Working Time, Wage Assessment, Poverty, Migrant Labor, Collective Bargaining, Social Benefits.
Health and safety	Injuries and Fatalities and Toxics and Hazards
Human rights	Indigenous Rights, Gender Equity, High Conflict
Governance	Legal System and Corruption
Community infrastructure	Drinking-Water, Improved Sanitation, Hospital Beds

Source: Own creation

It is also relevant to determine w*hat social impacts operationalize each social issue* following the SHDB methodology and its process for doing that:

- *Data collection* (Benoit-Norris et al., 2012): For each social impact assessment, the SHDB collects data from international organizations such as the WHO, the ILO or the World Bank, among others. It incorporates over 200 publicly available data sources, which adopt criteria of comprehensiveness, legitimacy of the data source, reliability of method(s) used to collect data by the source, quantitative indicators, and relevance to the theme investigated.
- *Characterization* (Benoit et al., 2015): It is developed for presenting the level of risk associated with every social impact category, based on distributions of the data, literature review, or expert knowledge.
- *Social Hotspot Index Calculation* (Benoit et al., 2015): it is calculated using a weighted sum methodology of the social impacts measured, considering only negative impacts.

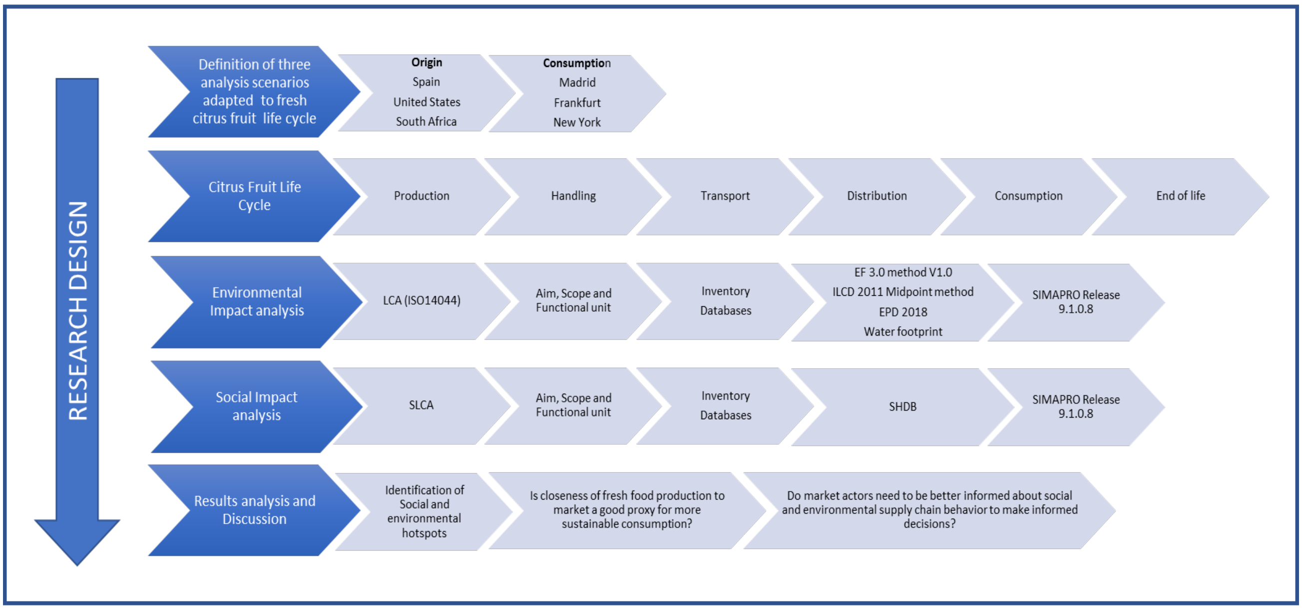
Furthermore, the SHDB enables users to identify all potentially relevant social issues and to analyze information grouped under social category and impact category, which reduces the possibility of offsetting bad scores with good scores in social impact measurement and allows exploring every potentially relevant social issue separately .

The selection of social indicators and their assessment in SHDB follow a technical approach that identifies social hotspots consistently with the concept of social sustainability in supply chains (Benoit et al., 2015). In addition, it integrates a multi-actor perspective which helps to make a backward/forward analysis of the social information of different countries and sectors involved in the supply chain of a product. Moreover, it integrates stakeholders' needs, since social issues are associated with different parties such as workers, indigenous peoples, migrants or communities. This quantification can be considered as the social footprint of the analyzed organization, since a footprint describes '*how human activities can impose different types of burden or impact on global sustainability'* (Power, 2009) and the social footprint is a measure to quantify the social sustainability performance of a product. Social hotspots are identified based on the quantification of the Social Footprint for the different empirical scenarios.

3. Research design

Research design (Figure 3) involves five steps that allow us to illustrate the complexity which arises from global food markets. Our aim is to thoroughly explore the social and environmental impact of production and consumption of fresh food so as to contribute to promoting dialog on sustainability along supply chains and to tracing the origin of those impacts.

Figure 3: Flow chart of the study



To begin with, we define three scenarios to answer our research question. The first step offers three possible production and consumption alternatives where the impact of closeness to the market can be observed. We have selected the fresh orange life cycle as an example and figure 4 and table 5 show three global scenarios, based on real trade, under which an analysis and a comparison of the main fresh orange production and consumption environmental and social hotspots are made. The product movements along the supply chain have been defined with the help of citrus fruit market experts. Consumption scenario 1 relates to the market in Madrid, the most important fruit and vegetable market in Spain. Scenario 2 focuses on the consumption of fresh oranges in Central Europe, using Frankfurt as an example of how important that central market is in Germany and scenario 3 tries to capture the fresh orange market in the USA, with New York as a case study. For each scenario, different fruit origins have been defined, considering three of the most important orange producing countries (table 4): Spain (Valencia), United States (California) and South Africa (Limpopo), as fresh fruit suppliers.

Table 4: World orange production, 2018 for major producers and the rest of the world

Producer Area	Tons
Brazil	16,713,534
China	9,246,305
China, mainland	9,103,908
India	8,367,000
United States of America	4,833,480
Mexico	4,737,990
Spain	3,639,853
Egypt	3,246,483
Indonesia	2,510,442
Turkey	1,900,000
Iran (Islamic Republic of)	1,889,252
South Africa (ZA)	1,775,760
Rest of the world	16,695,673

Source: FAO http://www.fao.org/faostat/en/#data/QC

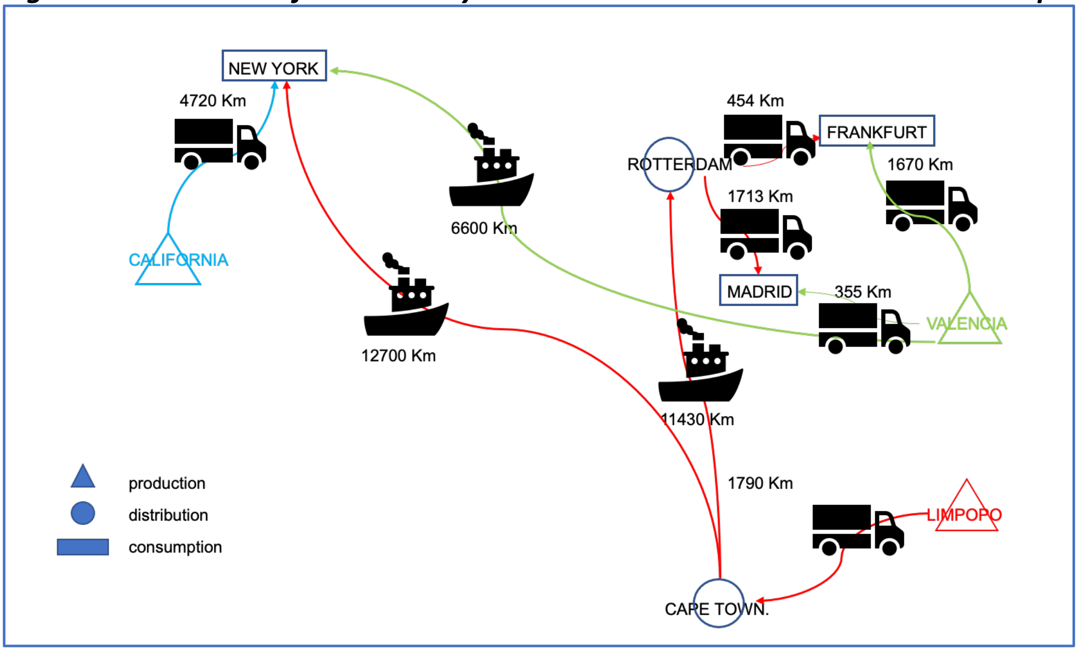
Table 5: Scenario characterization

Orange Production Area	Production (,000 Tonnes)	Exports (%) (,000 Tonnes)	Imports (,000 Tonnes)	Destination Madrid (Scenario 1)	Destination Frankfurt (Scenario 2)	Destination New York (Scenario 3)
SPAIN (Valencia)	3641,1	1870,5 (51,37)	163,4	Yes	Yes	Yes
US (California)	5371,0	550,0 (10,24)	160,0	No	No	Yes
ZA (Limpopo)	1560,0	1064,1 (68,21)	3,5	Yes	Yes	Yes

Source: FAO Citrus Fruit (Fresh and Processed) Statistical Bulletin 2016. Trade and Markets Division (Rome, 2017)

In scenario 1, we compare the environmental and social impacts created by a kilo of fresh oranges consumed in Madrid and produced in Valencia (Spain) or Limpopo (South Africa). In the first alternative, we highlight the proximity to the domestic market while in the second one, oranges are imported through the Port of Rotterdam (the most habitual way to introduce South African citrus fruit in the European Union and distributed in Madrid). Scenario 2 allows us to compare an important European food market, Frankfurt (Germany) with two different product origins, the Spanish origin, which we characterize as domestic market type 2, as Germany and Spain are members of the European single market; and South African imports. In scenario 3, New York (USA) market offers the possibility to analyze big domestic markets and compare with long-distance orange fruit supply chains to properly examine the different sources of impacts along product life cycles.

Figure 4: Scenarios defined to analyze the main social and environmental hotspots



Secondly, we have adapted a standardized fresh food life cycle to fresh orange supply chain aim and scope. According to the information analyzed from different sources (academic literature and sectoral guidelines and standards), a generic structure of a fresh orange product life cycle has been devised under the Product Category Rules (PCRs) (2019-08-19, Fruits and Nuts (UN CPC 013) Version 1.01). PCRs organize fruit life cycle in three subsystems, upstream or “from cradle to gate”, core-stream or “from gate to gate” and downstream, introducing the transportation phase to the end users and “end of life”.

As the objective of this analysis is to determine if distance from production to consumption is a good proxy for making more wiser sustainability-based decisions, including more sustainable consumption, we will not address some of the life cycle stages as they are of no use for comparative purposes. Moreover, this scope definition smoothers mismatches out, as the redundant phases in the three scenarios have not been considered.

The third and fourth research phases relate to the environmental and social impact analysis. At this stage of research, we have defined the use of different life cycle assessment standards for the environmental and social impact analysis. In order to implement SLCA analyses and standardize SLCA, we have applied ISO14044 (ISO, 2006a) and ISO14040 (ISO 2006b) for environmental purposes; and S-LCA (UNEP-SETAC, 2009), the Methodological Sheets for Subcategories developed under this framework (UNEP-SETAC, 2013), and the Social Hotspots Database (SHDB) related to them (Benoit-Norris et al., 2012). For practical purposes, we have followed four phases: Aim and Scope definition, inventory analysis, impact assessment and interpretation.

Thus, the reader should bear in mind that the scope of this study is reduced to key phases: upstream (growing), corestream (production) and downstream (transport and distribution).

The functional unit (declared unit) chosen for this research is one kilogram of fresh grade oranges (Navelina), meant for direct human consumption and used for the export market, conventionally grown (not including its packaging) at the point where the product arrives at the customer gate. This means three different locations of origin and three different sales locations. This paper uses a declared unit instead of a functional unit, since covering all the functional and qualitative aspects in the same unit is not possible, nor applying PCR for fruits and nuts (EPD 2019:01 version 1.01, valid until 2023-01-21). This has been used in other studies on citrus fruit LCA (among others: Beccali et al., 2010; Lo Giudice et al., 2013; Nicolo et al., 2017). Table 6 summarizes the most relevant inputs from the environmental and social (toxics and hazards) perspective for the production phase and for these three scenarios. The environmental inventory data come from ECOINVENT v3 DATABASE Compiled October 2016, EF Database 2.0 and Agri-Footprint v3.0 March 2017. For social inventory data, we use the SHDB v2.1 database. We have also checked (Table 6) the quality of the data using the Data Quality Rating (DQR) provided by Ecoinvent. This means that USA data is of outstanding quality, South Africa data is of very good quality and the quality of data from Spain is good.

Table 6: relevant inputs for production phase in the three scenarios

Inputs	ZA	USA	ES
DQR	1.7	1.2	2.2
Productivity Ton/Ha	34,7	32	30
Irrigation m3/Ha	2682	4457	4187
NPK kg/Ha	80-80-72	95-38-45	300-65-135
Solid manure Ton/Ha	0	0	3,6
IA pesticides kg/Ha	5,3	11	14
Agricultural oils kg/Ha	0	8,8	74,7

Source ECOINVENT v3 DATABASE

In the Environmental Life Cycle Impact Assessment, we have adopted different methods for assessing environmental impacts: ILCD 2011, EF 3.0, EPD (2018) provided by

Environdec and the water scarcity assessment method (Hoekstra et al.,2012). Following different methods to calculate environmental impacts has improved the robustness of the analysis and results.

The ILCD 2011 Midpoint method was developed by the European Commission, Joint Research Centre in 2012. It provides recommendations on the correct use of characterization factors for impact assessment; which are produced in the ILCD guidance document "Recommendations for Life Cycle Impact Assessment in the European context- based on existing environmental impact assessment models and factors (ILCD, 2011)". The EF 3.0 Method v1.00 is the impact assessment method of the Environmental Footprint initiative during the EF transition phase. It includes the normalization and weighting factors published in November 2019. The International EPD System (2019) method is the successor of EPD from 2013 and is intended for the creation of Environmental Product Declarations (EPDs), published on the website of the Swedish Environmental Management Council (SEMC).

In the case of the Social Life Cycle Assessment, the SHDB_Ecoinvent_Hybrid_2017_v1_version84 method comprises eighteen Social Themes Tables, which fall under five social categories (Labor Rights, Health & Safety, Human Rights, Governance and Community). The SHDB_Ecoinvent_Hybrid_2017_v1_version84 assesses life cycle impacts as a quantitative social impact related to production and consumption as a characterization model.

All the collected data were processed using SIMAPRO Release 9.1.0.8, one of the most used software in the world.

Table 7 shows the environmental impact categories included in this study. These impact categories are linked with the impact categories defined in EPD. As EPD is a generic product category rule for fruits and nuts, we have ensured that the EPD impacts are also considered in the environmental footprint methods used in this research, ILCD2011 and EF 3.0.

Table 7: Environmental impacts

EPD	PEF
GWP	climate change
acidification	acidification
eutrophication	terrestrial/freshwater/marine eutrophication
photochemical oxidant	photochemical ozone
water scarcity	water resource scarcity/freshwater ecotoxicity
use of resources	mineral and fossil

Source: Own creation

The last part of the study presents an analysis of the results, identifies the environmental hotspots and includes a discussion of those results. Given the diversity of the measurement units shown in Table 2 and to compare results among scenarios, weighting systems have been implemented according to the different impact assessment methods. The higher the value, the more significant the environmental impact. A similar process has been used to calculate social impacts, and comparisons can be drawn between the five social categories: Labor Rights, Health & Safety, Human Rights, Governance and Community, but not among them.

4. Results

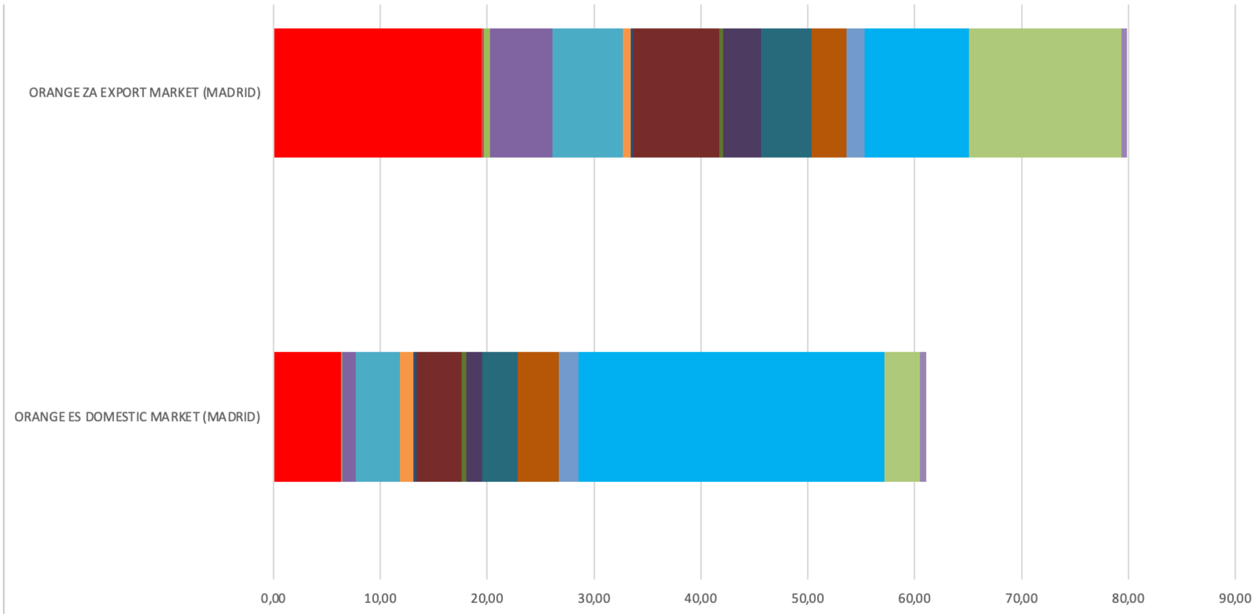
This section presents the results obtained from the analysis of the environmental and social hotspots of citrus fruits along its whole supply chain, focusing on the origin of this food product and its closeness to the market in the three designed scenarios. These findings will allow determining whether proximity of food production to markets is a good proxy indicator for market actors to take more sustainable decisions or whether their behavior needs to be modified to broaden their knowledge of supply chains so that they can make informed decisions.

Results are organized as follows. For each scenario, both environmental and social LCA is included, which results in environmental footprint and social footprint calculation respectively. In addition, concerning the environmental dimension, it differentiates information regarding environmental impacts by impact category in the most representative life cycle phases (production in origin and transport to final market). Consequently, it is possible to analyze the environmental impact 'produced' in origin (unit µPt), and its relative importance compared to the transport phase, considering the cumulative impact contribution of each life cycle phase to the total environmental impact (in percentage terms). Moreover, regarding the social dimension, information about social impacts is divided into social category and impact category (subcategory). In this case, disaggregated information by life cycle phase is not included due to the marginal relevance of the transport phase in social terms, compared with the production phase.

4.1. *SCENARIO 1: Market: Madrid (Spain) + Fresh fruit suppliers: DOMESTIC-Spain (Valencia ES) vs EXPORT-South Africa (Limpopo ZA)*

In this scenario, Madrid is the reference market and Valencia is the fresh fruit supplier; thus, the short supply chain is shortened, ~~in this case, defines Valencia as the origin for fresh fruit suppliers~~. Figure 5 shows a comparison between oranges from Valencia and oranges from South Africa in terms of environmental footprint impact categories. An initial analysis shows that the environmental impact of South African oranges is higher than that of Valencian ones; which may indicate that Spanish oranges could be, apparently, more sustainable in this context and, therefore, that shorter supply chains might be more sustainable. Nevertheless, it is relevant to carry out an in-depth analysis to determine whether disaggregated information reinforces that statement or, on the contrary, could evade relevant issues to be considered by market actors in their decision-making process under a sustainable approach.

Figure 5: Environmental impact categories weighted (Market: Madrid)



	ORANGE ES DOMESTIC MARKET (MADRID)	ORANGE ZA EXPORT MARKET (MADRID)
Climate change	6,3067	19,4465
Ozone depletion	0,0320	0,2161
Ionising radiation	0,1178	0,5840
Photochemical ozone formation	1,2357	5,8353
Particulate matter	4,1362	6,6077
Human toxicity, non-cancer	1,2762	0,7296
Human toxicity, cancer	0,2491	0,2103
Acidification	4,2652	8,1141
Eutrophication, freshwater	0,4574	0,3364
Eutrophication, marine	1,4856	3,5653
Eutrophication, terrestrial	3,2732	4,7109
Ecotoxicity, freshwater	3,8997	3,2653
Land use	1,8122	1,6941
Water use	28,6415	9,7336
Resource use, fossils	3,2879	14,3340
Resource use, minerals and metals	0,6454	0,4750

By environmental impact category, oranges from Limpopo present higher scores mainly in 'Climate change' (6.31 vs 19.45 µPt), 'Resource use, fossils' (3.29 µPt vs 14.33 µPt) and 'Photochemical ozone formation' (1.24 µPt vs 5.84 µPt). However, oranges from Valencia show the worst behavior in terms of 'Water use' (28.64 µPt vs 9.73 µPt).

In addition, by life cycle phase (Table 8), considering the impacts created at the origin of the product, more than 90% of the impact of the South African product, <u>in terms of how big differences are in the three categories</u>, is generated in the transport phase, not in the production phase. As a result, if this phase is eliminated, the footprint in origin in all the contemplated categories is lower in Limpopo than in Valencia.

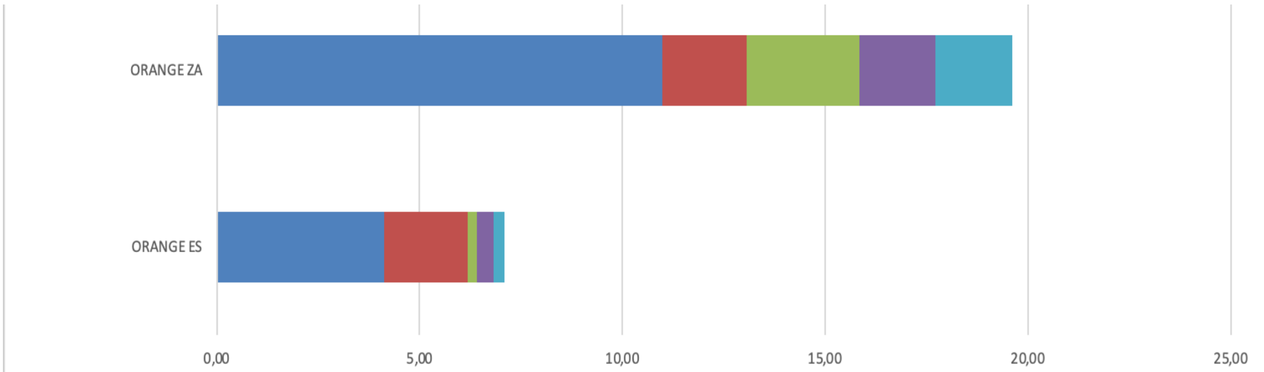
Table 8: Environmental footprint by origin and the production of cumulative impacts+ transportation life cycle phases (Market: Madrid)

Impact Category	**Environmental footprint in origin Valencia vs Limpopo**		**Cumulative environmental impact contribution of each life cycle phase (%)**	
		Export	***Domestic***	***Export***

	Domestic ORIGIN Valencia (µPt)	ORIGIN Limpopo (µPt)	ORIGIN Valencia (%)	Transport Valencia-Madrid (%)	TOTAL Valencia Madrid (%)	ORIGIN Limpopo (%)	Transport Limpopo-Madrid (%)	TOTAL Limpopo-Madrid (%)
Climate change	5.05	0.88	80.12	19.88	100	4.54	95.46	100
Ozone depletion	0.02	0.01	58.54	41.46	100	3.46	96.54	100
Ionizing radiation	0.08	0.04	68.79	31.21	100	6.04	93.96	100
Photochemical ozone formation	1.16	0.33	94.16	5.84	100	5.68	94.32	100
Particulate matter	3.72	1.44	90.04	9.96	100	21.76	78.24	100
Human toxicity. non-cancer	1.24	0.24	97.31	2.69	100	32.84	67.16	100
Human toxicity. cancer	0.25	0.14	98.43	1.57	100	64.26	35.74	100
Acidification	4.16	1.58	97.49	2.51	100	19.52	80.48	100
Eutrophication. freshwater	0.46	0.31	99.76	0.24	100	92.88	7.12	100
Eutrophication. Marine	1.46	1.27	98.48	1.52	100	35.74	64.26	100
Eutrophication. terrestrial	3.24	1.20	98.94	1.06	100	25.44	74.56	100
Ecotoxicity. freshwater	3.78	1.58	96.98	3.02	100	48.39	51.61	100
Land use	1.81	1.45	99.96	0.04	100	85.88	14.12	100
Water use	28.62	9.40	99.93	0.07	100	96.62	3.38	100
Resource use. Fossils	2.40	1.02	73.03	26.97	100	7.10	92.90	100
Resource use. minerals and metals	0.65	0.46	99.97	0.03	100	97.59	2.41	100

As far as the social footprint is concerned (Figure 6), the social category map reflects important differences between both citrus products. Oranges from Valencia achieved clearly better social scores regarding 'Labor right and decent work' (4.12 vs 10.99) as well as in the 'Human rights' (0.23 vs 2.78), 'Governance' (0.40 vs 1.87), and 'Community infrastructure' (0.28 vs 1.90) social categories. Nevertheless, oranges from Valencia and oranges from South Africa obtained almost the same score in the 'Health and safety' category (2.07 vs 2.08).

Figure 6: Social impact categories weighted (Market: Madrid)



	ORANGE ES	ORANGE ZA
Labor right and decent work	4,11635	10,98748
Health and safety	2,06846	2,07917
Human right	0,23214	2,77585
Governance	0,39777	1,86898
Community infraestructure	0,27705	1,90211

Table 10 disaggregates these results into social subcategories, which allows identifying the differences that have arisen from the specific social issue.

Table 10. Social footprint disaggregated by impact categories (subcategories) (Market: Madrid)

Social categories	**Impact categories (Subcategories)**	***Domestic* Valencia**	***Export* Limpopo**
Labor right and decent work	Child Labor	0.09	2.19
	Forced Labor	0.19	1.24
	Excessive Working Time	0.16	1.16
	Wage Assessment	1.74	2.69
	Poverty	0.19	1.28
	Migrant Labor	1.10	0.48
	Collective Bargaining	0.57	1.52
	Social Benefits	0.08	0.44
Health and safety	Injuries and Fatalities	1.25	0.81
	Toxics and Hazards	0.82	1.27
Human right	Indigenous Rights	0.04	1.05

Social categories	**Impact categories (Subcategories)**	***Domestic* Valencia**	***Export* Limpopo**
	Gender Equity	0.08	0.43
	High Conflict	0.11	1.30
Governance	Legal System	0.19	0.52
	Corruption	0.21	1.35
Community infrastructure	Drinking-Water	0.05	0.33
	Improved Sanitation	0.07	0.40
	Hospital Beds	0.16	1.17

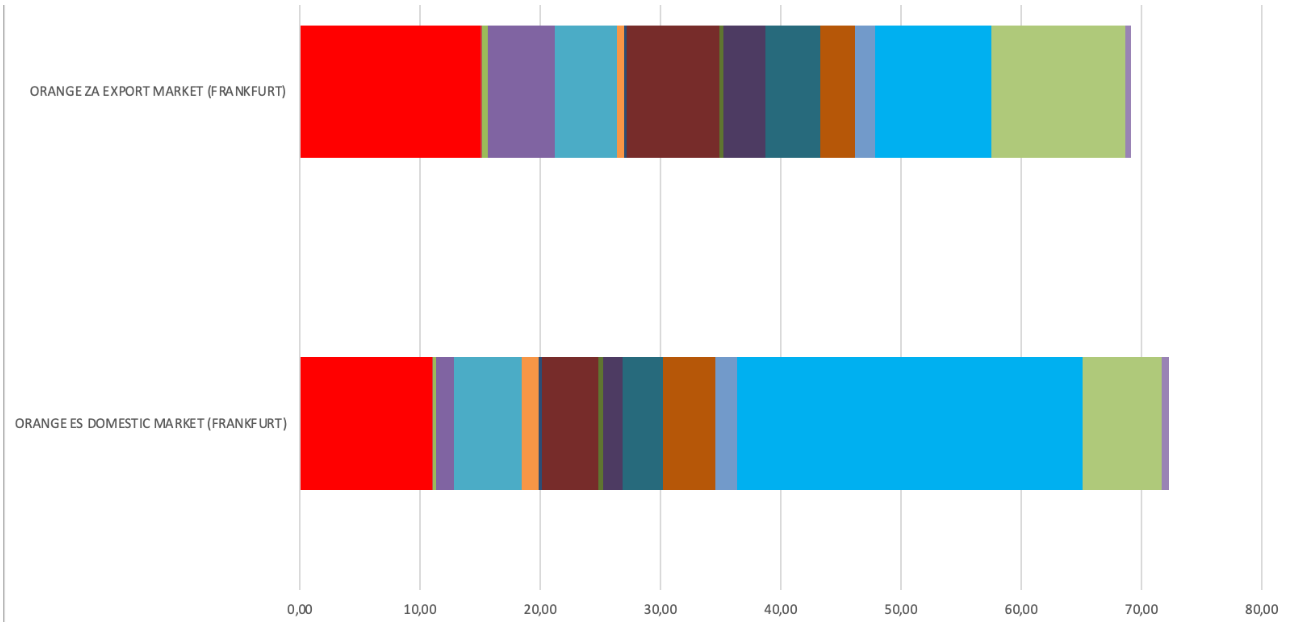
In this sense, concerning 'Labor right and decent work', it is relevant to highlight the low scores obtained by the Valencian product in all the cases except in the 'Migrant Labor' subcategory (1.10 vs 0.48). The orange from Valencia also has the highest scores in the 'Injuries and Fatalities' subcategory (1.25 vs 0.81). Apart from 'Labor right and decent work', other social impact categories specially relevant for the social footprint of oranges from South Africa are 'Indigenous rights' (0.04 vs 1.05),' High conflict' (0.11 vs 1.30), 'Corruption' (0.21 vs 1.35) and 'Hospital beds' (0.16 vs 1.17), associated to 'Human rights', 'Governance' and 'Community infrastructure' respectively.

4.2. *SCENARIO 2: Market: Frankfurt (Germany) + Fresh fruit suppliers: DOMESTIC - Spain (Valencia ES) vs EXPORT-South Africa (Limpopo ZA)*

This second scenario focuses on the social and environmental behavior of the citrus product studied from the perspective of a market located in Frankfurt. As it is explained before, in this case, the Spanish orange still represents the domestic product (so with a short supply chain within EU frontiers) and the South African orange the one with the longer supply chain.

Although both products are regarded as domestic/external products, their environmental impact varies as Figure 7 reflects. In this case, the environmental footprint of the orange from Valencia is slightly higher in global terms. Considering the disaggregated information, the domestic product still has achieved better scores in terms of the 'Climate change' (10.95 µPt vs 15.00 µPt), 'Photochemical ozone formation' (1.50 µPt vs 5.58 µPt) and 'Resource use, fossils' (6.57 µPt vs 11.19 µPt) impact categories, and has obtained worse results especially in the 'Water use' category (28.72 µPt vs 9.66 µPt). Nevertheless, since the orange from Valencia has gotten a higher score in the Transport phase impact, the difference between them has been narrowed (as can be seen in Table 11). Compared with the scenario focused on the Madrid market, the only difference is the Transport characterization, since the data in origin does not change. In addition, the short distance between Frankfurt and the port of Rotterdam has an impact on the 'contribution' of the Transport life cycle phase in the oranges from South Africa, which underlines the importance of freight transport mix alternatives (Muñoz-Torres et al., 2019). In addition, it is observed that its relevance in the environmental footprint regarding the most remarked environmental impact categories 'Climate change', 'Photochemical ozone formation' and 'Resource use, fossils' is higher for the market located in Madrid than for the market located in Frankfurt.

Figure 7: Environmental impact categories weighted (Market: Frankfurt)



	ORANGE ES DOMESTIC MARKET (FRANKFURT)	ORANGE ZA EXPORT MARKET (FRANKFURT)
Climate change	10,9520	14,9990
Ozone depletion	0,0811	0,1690
Ionising radiation	0,2539	0,4537
Photochemical ozone formation	1,5032	5,5792
Particulate matter	5,6622	5,1467
Human toxicity, non-cancer	1,4033	0,6079
Human toxicity, cancer	0,2637	0,1964
Acidification	4,6610	7,7351
Eutrophication, freshwater	0,4614	0,3325
Eutrophication, marine	1,5692	3,4852
Eutrophication, terrestrial	3,4017	4,5878
Ecotoxicity, freshwater	4,3354	2,8482
Land use	1,8146	1,6917
Water use	28,7195	9,6589
Resource use, fossils	6,5725	11,1893
Resource use, minerals and metals	0,6462	0,4743

Table 11: Environmental footprint by origin and cumulative impacts production + transportation life cycle phases (Market: Frankfurt)

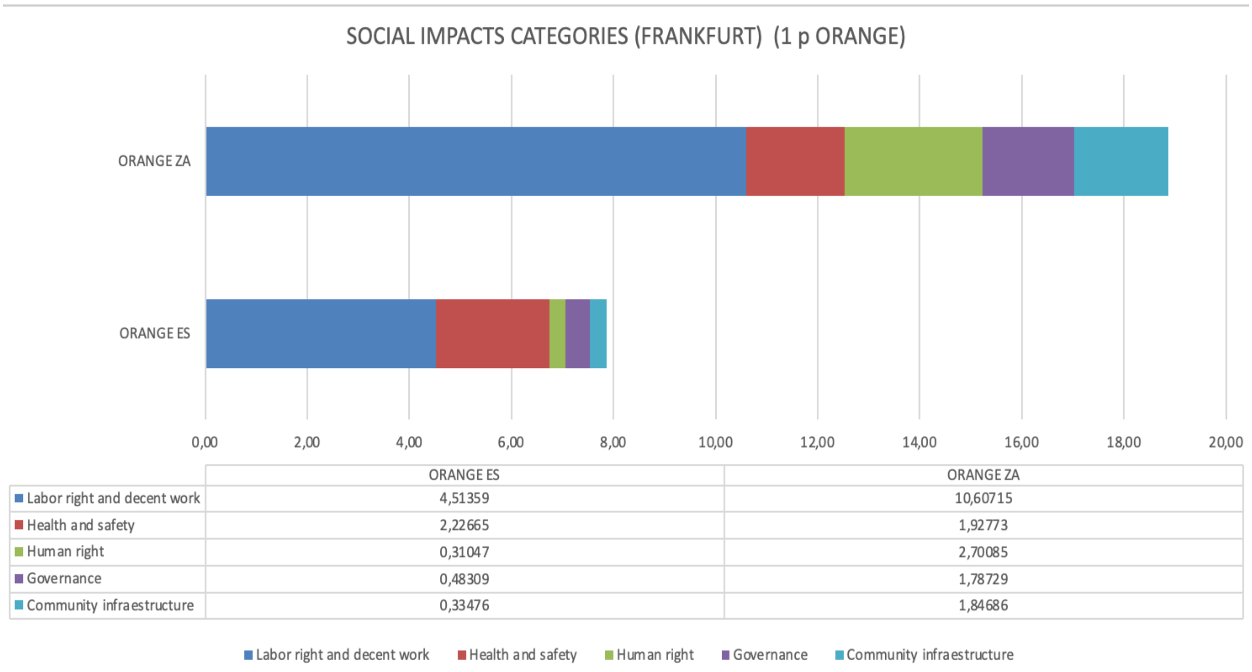
Impact Category	**Environmental footprint in origin Valencia vs Limpopo**		**Cumulative environmental impact contribution of each life cycle phase (%)**	
		Export	***Domestic***	***Export***

	Domestic ORIGIN Valencia (µPt)	ORIGIN Limpopo (µPt)	ORIGIN Valencia (%)	Transport Valencia-Frankfurt (%)	TOTAL Valencia Frankfurt (%)	ORIGIN Limpopo (%)	Transport Limpopo-Frankfurt (%)	TOTAL Limpopo-Frankfurt (%)
Climate change	5.05	0.88	46.13	53.87	100	5.89	94.11	100
Ozone depletion	0.02	0.01	23.09	76.91	100	4.42	95.58	100
Ionizing radiation	0.08	0.04	31.90	68.10	100	7.77	92.23	100
Photochemical ozone formation	1.16	0.33	77.40	22.60	100	5.94	94.06	100
Particulate matter	3.72	1.44	65.78	34.22	100	27.94	72.06	100
Human toxicity. non-cancer	1.24	0.24	88.50	11.50	100	39.41	60.59	100
Human toxicity. cancer	0.25	0.14	93.00	7.00	100	68.81	31.19	100
Acidification	4.16	1.58	89.22	10.78	100	20.48	79.52	100
Eutrophication. freshwater	0.46	0.31	98.89	1.11	100	93.96	6.04	100
Eutrophication. Marine	1.46	1.27	93.23	6.77	100	36.56	63.44	100
Eutrophication. terrestrial	3.24	1.20	95.20	4.80	100	26.12	73.88	100
Ecotoxicity. freshwater	3.78	1.58	87.24	12.76	100	55.48	44.52	100
Land use	1.81	1.45	99.83	0.17	100	86.00	14.00	100
Water use	28.62	9.40	99.65	0.35	100	97.37	2.63	100
Resource use. Fossils	2.40	1.02	36.53	63.47	100	9.09	90.91	100
Resource use. minerals and metals	0.65	0.46	99.85	0.15	100	97.74	2.26	100

The relevance of the social impact associated with the product studied in its origin brings about little change regarding the resulting social footprint when the destination market varies (Figure 8).

Figure 8: Social impact categories weighted (Market: Frankfurt)

Consequently, comparing oranges from Valencia and from Limpopo in social terms still shows a better social footprint, mainly due to the scores obtained by oranges from Valencia regarding 'Labor right and decent work' (4.51 vs 10.61), as well as in the 'Human right' (0.31 vs 2.70), 'Governance' (0.48 vs 1.79), and 'Community infrastructure' (0.33 vs 1.85) social categories. Likewise, the scores achieved in the 'Health and safety' category are similar; however, the scores obtained by oranges from Valencia are a little worse than those by the oranges from South Africa (2.23 vs 1.93).



Social categories	**Impact categories (Subcategories)**	***Domestic* Valencia**	***Export* Limpopo**
Labor right and decent work	Child Labor	0.12	2.16
	Forced Labor	0.22	1.20
	Excessive Working Time	0.18	1.14
	Wage Assessment	1.82	2.61

Social categories	Impact categories (Subcategories)	*Domestic* Valencia	*Export* Limpopo
	Poverty	0.23	1.24
	Migrant Labor	1.14	0.44
	Collective Bargaining	0.69	1.40
	Social Benefits	0.11	0.41
Health and safety	Injuries and Fatalities	1.30	0.76
	Toxics and Hazards	0.92	1.17
Human rights	Indigenous Rights	0.05	1.04
	Gender Equity	0.11	0.40
	High Conflict	0.15	1.26
Governance	Legal System	0.23	0.49
	Corruption	0.26	1.30
Community infrastructure	Drinking-Water	0.06	0.32
	Improved Sanitation	0.09	0.37
	Hospital Beds	0.19	1.15

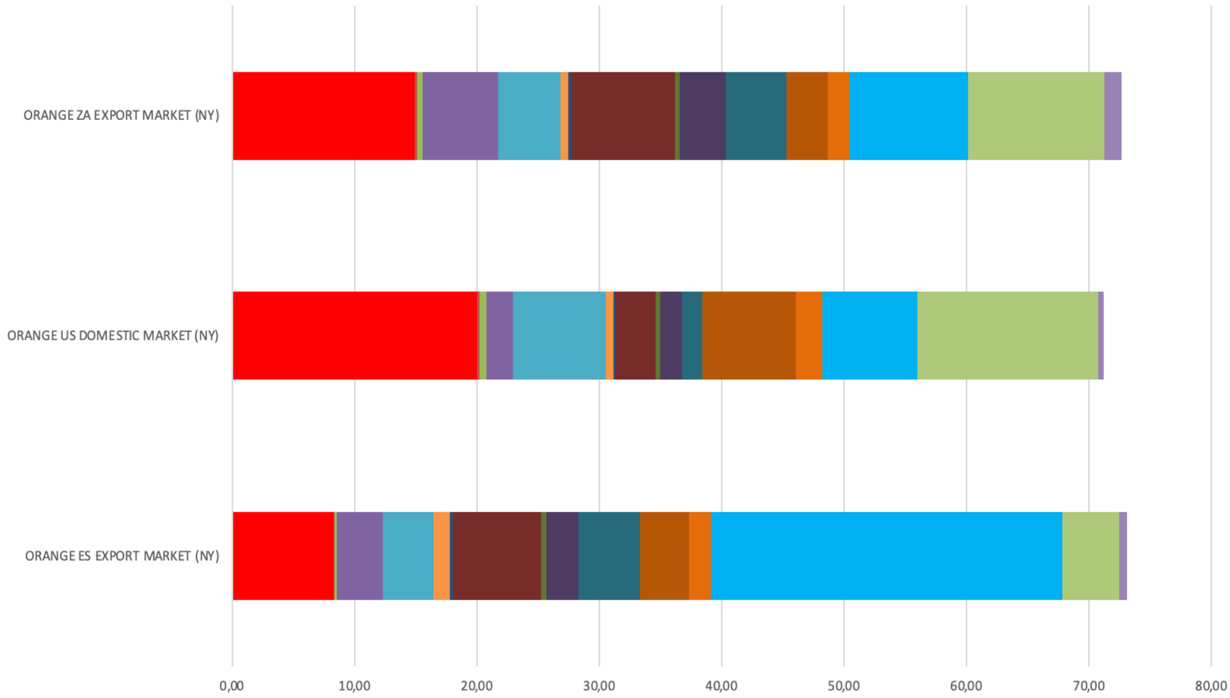
Table 12. Social footprint disaggregated by impact categories (subcategories)

Consistently, the picture remains invariable when data are disaggregated by social impact categories (Table 12). The orange from Valencia presents better scores than the South African ones in all social subcategories, except 'Migrant labor' (1.14 vs 0.44) and 'Injuries and fatalities' (1.30 vs 0.76). Moreover, differences are appreciated in the 'Labor right and decent work' category; and, in terms of, 'Indigenous rights' (0.05 vs 1.04), 'High conflict' (0.15 vs 1.26), 'Corruption' (0.26 vs 1.30) and 'Hospital beds' (0.19 vs 1.15) which belong to the 'Human rights', 'Governance' and 'Community infrastructure' categories.

4.3. *SCENARIO 3: Market: New York (US) + Fresh fruit suppliers: DOMESTIC- United States (California US) vs EXPORT- Spain (Valencia ES)/South Africa (Limpopo ZA)*

In the third scenario, there is a change in the continent of the destination market and a new market actor is added. The new market is located in New York (USA.), and oranges from California became the natural domestic product with shorter supply chains. Consequently, oranges from South Africa remain in its external product role besides the Spanish ones, which changes its cataloging to export product.

Figure 9: Environmental impact categories weighted (Market: New York)



	ORANGE ES EXPORT MARKET (NY)	ORANGE US DOMESTIC MARKET (NY)	ORANGE ZA EXPORT MARKET (NY)
Climate change	8,3004	19,9853	14,9260
Ozone depletion	0,0588	0,2070	0,1644
Ionising radiation	0,1742	0,6050	0,4432
Photochemical ozone formation	3,7717	2,1160	6,1734
Particulate matter	4,1320	7,6254	5,0995
Human toxicity, non-cancer	1,3202	0,6109	0,6680
Human toxicity, cancer	0,2594	0,1652	0,2641
Acidification	7,2030	3,2506	8,4528
Eutrophication, freshwater	0,4586	0,3961	0,3937
Eutrophication, marine	2,6165	1,8172	3,7388
Eutrophication, terrestrial	5,0067	1,6581	4,9796
Ecotoxicity, freshwater	4,0295	7,5953	3,3586
Land use	1,8124	2,1769	1,7601
Water use	28,6750	7,7532	9,7155
Resource use, fossils	4,6633	14,7830	11,1061
Resource use, minerals and metals	0,6457	0,4777	1,4190

The environmental footprint represented in Figure 9 shows small differences between the data obtained by the three citrus products in total score, the oranges from California obtained the lowest score (US 71.22 µPt vs ES 73.13 µPt and ZA 72.66 µPt). However, when comparing the domestic product with the exported one by impact category, several issues arise.

In the case of the orange from Valencia *versus* the orange from California, it is possible to observe that the main difference lies in the high impact of the Spanish orange in 'Water use' (7.75 µPt vs 28.68 µPt). This is offset by how poorly oranges from California perform in other environmental impact categories such as 'Climate change' (19.99 µPt vs 8.30 µPt) or 'Resource use, fossils' (14.78 µPt vs 4.66 µPt).

Regarding oranges from Limpopo *versus* California, the domestic product shows dramatically worse data in the 'Climate change' (19.99 µPt vs 14.93 µPt), 'Ecotoxicity, freshwater' (7.60 µPt vs 3.36 µPt), and 'Resource use, fossils' (14.78 µPt vs 11.11 µPt) impact categories; however, better data is gathered in terms of 'Photochemical ozone formation' (2.12 µPt vs 6.17) and 'Acidification' (3.25 µPt vs 8.45) impact categories.

With regard to life cycle phase (Table 13), the Transport phase causes more than 50% of the environmental footprint of the orange from Valencia in the 'Ozone depletion', 'Ionizing radiation', and 'Photochemical ozone formation' impact categories. Yet, none of them are deemed relevant in the_(USA-Spain) comparison, so the Transport phase could not have had an impact on the decision-making process. Concerning oranges from Limpopo, the Transport phase 'adds' more than 50% of the environmental impact created in origin in almost every impact category.

Considering the environmental impact achieved in origin, the domestic product presents better results than the orange from Valencia in every impact category except 'Ecotoxicity, freshwater', where the orange from California shows the best data (5.78 µPt vs 3.78). However, the prioritization between oranges from California and from Limpopo is not so clear; except regarding 'Ecotoxicity, freshwater' (5.78 µPt vs 1.58); significant differences between the diverse impact categories in origin between both products are not observed.

Table 13: Environmental footprint by origin and cumulative impacts production + transportation life cycle phases (Market: New York)

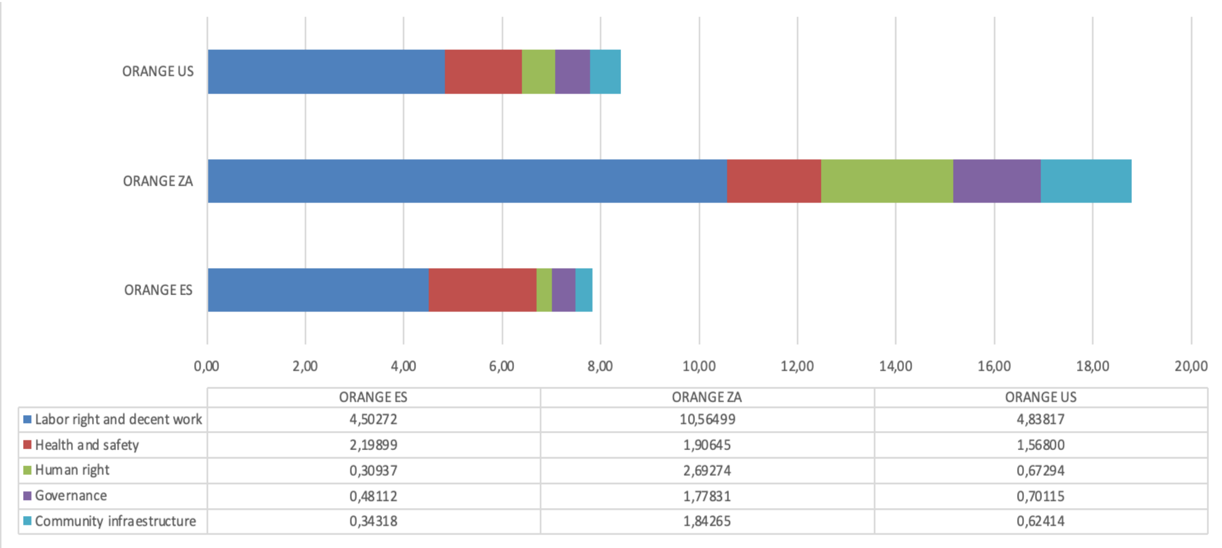
Impact Category	**Environmental footprint in origin Valencia vs Limpopo vs California**			**Cumulative environmental impact contribution of each life cycle phase (%)**								
				Domestic			***Export***			***Export***		
	Domestic **ORIGIN California (µPt)**	***Export*** **ORIGIN *Valencia (µPt)***	***Export*** **ORIGIN Limpopo (µPt)**	**ORIGIN California (%)**	**Transport California - New York (%)**	**TOTAL California New York (%)**	**ORIGIN Valencia (%)**	**Transport Valencia-New York (%)**	**TOTAL Valencia New York (%)**	**ORIGIN Limpopo (%)**	**Transport Limpopo-New York (%)**	**TOTAL Limpopo-New York (%)**
Climate change	1.82	5.05	0.88	9.12	90.88	100	60.87	39.13	100	5.92	94.08	100
Ozone depletion	0.01	0.02	0.01	4.09	95.91	100	31.87	68.13	100	4.54	95.46	100
Ionising radiation	0.05	0.08	0.04	8.46	91.54	100	46.51	53.49	100	7.96	92.04	100
Photochemical ozone formation	0.43	1.16	0.33	20.41	79.59	100	30.85	69.15	100	5.37	94.63	100

Particulate matter	1.10	3.72	1.44	14.39	85.61	100	90.13	9.87	100	28.20	71.80	100
Human toxicity. non-cancer	0.11	1.24	0.24	18.45	81.55	100	94.07	5.93	100	35.87	64.13	100
Human toxicity. cancer	0.08	0.25	0.14	49.59	50.41	100	94.52	5.48	100	51.18	48.82	100
Acidification	1.29	4.16	1.58	39.83	60.17	100	57.73	42.27	100	18.74	81.26	100
Eutrophication. Freshwater	0.36	0.46	0.31	90.22	9.78	100	99.50	0.50	100	79.35	20.65	100
Eutrophication. marine	1.33	1.46	1.27	73.23	26.77	100	55.91	44.09	100	34.08	65.92	100
Eutrophication. Terrestrial	0.91	3.24	1.20	55.04	44.96	100	64.68	35.32	100	24.07	75.93	100
Ecotoxicity. freshwater	5.78	3.78	1.58	76.07	23.93	100	93.86	6.14	100	47.05	52.95	100
Land use	1.56	1.81	1.45	71.60	28.40	100	99.95	0.05	100	82.66	17.34	100
Water use	7.40	28.62	9.40	95.48	4.52	100	99.81	0.19	100	96.80	3.20	100
Resource use. fossils	1.28	2.40	1.02	8.67	91.33	100	51.49	48.51	100	9.16	90.84	100

Resource use. minerals and metals	0.45	0.65	0.46	94.71	5.29	100	99.92	0.08	100	32.67	67.33	100

Concerning the social dimension, the exported product from Valencia has the lowest social footprint (US 8.40 vs ES 7.84 and ZA 18.79), mainly due to the 'Labor right and decent work' social impact category which, in addition, makes oranges from South Africa present the highest social footprint (US 4.84 vs ES 4.50 and ZA 10.56).

Figure 10: Social impact categories weighted (Market: New York)



However, by subcategory (Table 14) the domestic product has a lower social impact in terms of 'Wage Assessment' (US 0.96 vs ES 1.82 and ZA 2.60), 'Migrant Labor' (US 0.29 vs ES 1.14 and ZA 0.44), and 'Toxics and Hazards' (US 0.67 vs ES 0.91 and ZA 1.16).

Table 14. Social footprint disaggregated by impact categories (subcategories) (Market: New York)

Social categories	**Impact categories (Subcategories)**	***Domestic* California**	***Export* Valencia**	***Export* Limpopo**
Labor right and decent work	Child Labor	0.32	0.12	2.16
	Forced Labor	0.31	0.22	1.20
	Excessive Working Time	0.24	0.18	1.13
	Wage Assessment	0.96	1.82	2.60
	Poverty	0.36	0.23	1.24
	Migrant Labor	0.29	1.14	0.44
	Collective Bargaining	1.67	0.68	1.39
	Social Benefits	0.68	0.12	0.41
Health and safety	Injuries and Fatalities	0.89	1.29	0.75

Social categories	Impact categories (Subcategories)	*Domestic* California	*Export* Valencia	*Export* Limpopo
	Toxics and Hazards	0.67	0.91	1.16
Human right	Indigenous Rights	0.07	0.05	1.03
	Gender Equity	0.24	0.11	0.40
	High Conflict	0.36	0.15	1.26
Governance	Legal System	0.36	0.23	0.48
	Corruption	0.34	0.25	1.29
Community infrastructure	Drinking-Water	0.15	0.06	0.32
	Improved Sanitation	0.21	0.09	0.37
	Hospital Beds	0.26	0.19	1.15

5. Discussion

The results of this study provide insights regarding how consistent the decisions market actors take based on proximity or short supply chains and the holistic concept of sustainability are. Moreover, complexity and the number of impacts are key factors that influence the selection of suppliers and the creation of buying decision-making design in order to address strategic objectives. Diverting attention away from how the product is managed at its origin and using proximity as a proxy for sustainability could hide social or environmental inefficiencies in relevant sustainability issues, which might cover possible mismanagement. In addition, it is necessary to consider the real relevance of the transport phase in the social and environmental footprint of products in order to offer a sustainable and satisfactory definition of the best available transport mix both in the internal management of companies and in public policy design. Moreover, social and environmental hotspots along the whole supply chains could be included in international trade agreements, as in the case of the EU 'Farm to Fork' strategy, '*to ensure a successful global transition, the EU will encourage and enable the development of comprehensive, integrated responses benefiting people, nature and economic growth*' (European Commission, 2020). From the perspective of consumers, the results obtained show that having information regarding the origin of the product to make sustainability-based decisions is insufficient, which stresses the need to incentivize food chain controls. On the other hand, making science-based sustainability assessments, may promote competitiveness within sustainability boundaries and reinforce disclosure and communication.

Apart from sustainability, food production and consumption deserve proper consideration (including economic considerations); especially when public policies implemented the promotion of domestic products. Food Autonomy has also become crucial, and the impact of the pandemic has accentuated inequalities. In this context, striking a balance is a difficult (if not impossible) task, which implies a complex process where questions such as social and environmental hotspots, global challenges and sociopolitical considerations are integrated. However, the need to advance in sustainability assessment tools design and their inclusion in available and intelligible information for decision-makers at different levels is clear. Being or not being sustainable should elicit an unequivocal response from every market actor; yet, the contextual information market actors need may differ. In order to address this issue, they should be able to have access to available reports which contain enough, accurate and homogeneous data, which will help them to make more wiser choices.

The new Common Agricultural Policy (CAP), which supports organic farming, recognizes the challenge posed by the lack of temporary staff. On the other hand, Chapter II (Objectives and Principles of Organic Production) of the regulation (EU) 2018/848 on organic production and labelling of organic products does not tackle, in any section, the essential issue of introducing social aspects as well as environmental ones in the framework for analyzing sustainability.

In this sense, the new CAP must be an effective instrument to support the profitability of production based on the respect for the environment and it must be oriented towards a comprehensive sustainability perspective that includes social aspects that should be certified at origin.

The development of this research presents some limitations. Despite being based on expert knowledge, the definition of scenarios and the selection of one product for a simulated domestic-export product is a simplification of business reality. In addition, although technical databases are the best available option for obtaining science-based conclusions, it is necessary to consider that life cycle assessment databases can present limited information on certain geographical areas or sectors, even though this research used the indicators provided by databases in which data quality is ensured.

6. Conclusions

1.This study presents the analysis of, the comparison between and the discussion about sustainability impacts of different market strategies along the supply chain. These impacts are created when the citrus fruit is produced in three big citrus fruit producing countries, Spain, South Africa and the United States and consumed in different domestic and export markets. As Figure 4 shows, three scenarios in which countries of origin have been defined for orange production: Valencia in Spain, Limpopo in South Africa and California in the United States . The product is handled there and then is transported to different markets in Europe, and the USA. Different life cycles have been identified, taking into account the production phase and transport to distribution nodes and the final destination/consumption phase. Therefore, the product life cycle has been adapted to different scenarios of production and consumption.

2.Agricultural techniques and orchard management play an important role in the sustainability of food production and there is an increasing number of research papers which deal with food cradle-to-gate life cycle assessment. Moreover, there is also an emerging body of research based on short food supply chains and whether or not proximity can be a proxy for sustainability in the agri-food system. The objective of this analysis is to consider the most relevant social and environmental impacts identified in the EF and the SLCA and the crucial hotspots for the citrus fruit sector. In addition, this paper attempts to study the relevance of the length of citrus fruit supply chains on its social and environmental impact map, in order to reach more wiser sustainability-based decisions.

3.Results obtained show mixed conclusions regarding the relevance and implications of choosing short food supply chains for achieving more sustainable food systems.

4.Placing Madrid as a destination market makes the orange from Valencia a proximity product. Considering the information provided by both the EF and the SLCA, it seems to be also the most sustainable option, since this product presents the lowest environmental and social footprint total score. Yet, despite the fact that this result shows the positive relationship between short supply chains and sustainability, not analyzing what is happening in the different life cycle stages and their sustainability implications could lead to potential mismanagement of social and environmental inefficiencies in the production of domestic products, in this case, especially regarding 'Water use' and 'Migrant Labor'.

5.In the case of the Frankfurt market, the domestic product (the orange from Valencia) presents better social behavior than the export product, but in environmental terms, it does not have the lowest footprint (oranges from Limpopo present the best EF total score). Consequently, the best sustainability results of shorter supply chain products are only partially obtained in this scenario. However, even in this situation, the complexity of impact categories requires a thorough analysis of the product both at the origin stage and at the transport phase, which will boost the efficiency in social and environmental management.

6.Finally, when analyzing the New York market scenario, the situation is similar. Oranges from California (domestic product) favor more sustainable choices in environmental terms (minor differences have arisen between the other two products analyzed). However, regarding the social dimension, oranges from Valencia have obtained the best SLCA total score. On the other hand, results reflect the need to identify the social and environmental behavior of products under analysis, disaggregated by life cycle phase and impact category, for detecting social and/or environmental inefficiencies.

Future research therefore should further explore these conclusions in different geographical areas and with other products. Moreover, future studies could integrate the perception of the market actors involved and the results obtained so as to enrich previous studies in terms of quantitative and science-based information.

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