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Social Life Cycle Analysis of Intensive Greenhouse Farming: A Qualitative View of Tomato Production in Almeria (Spain)

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Abstract: This paper presents an exploratory qualitative Social Life Cycle Analysis (S-LCA) of intensive greenhouse tomato farming in Almeria, Spain, with a specific focus on the social impacts on migrant workers. By setting as a functional unit the production of 10 kg of greenhouse tomato, the study investigates the social dynamics and challenges faced by migrant workers within the industry. The research sheds light on the negative aspects of intensive greenhouse farming for migrants, i.e., labor conditions, health and safety risks, social inequality, and exploitation of migrant labor. Utilizing document analysis, this study contributes to the field of S-LCA by providing a nuanced understanding of the social dimensions surrounding tomato production and migrant workers' experiences. It emphasizes the need for sustainable practices, improved labor conditions, and ethical considerations to ensure a socially responsible tomato farming industry. The findings have implications for policymakers, industry stakeholders, and consumers, providing insights for informed decision-making and the promotion of socially sustainable agricultural practices that prioritize the well-being and rights of migrant workers in the context of intensive greenhouse farming in Almeria.

Keywords: social life cycle analysis; tomato; Almeria; Spain; migrants

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1. Introduction

In the middle of the 20th century, questions emerged around the impact that human actions have on the environment and the consequences they could have for present and future generations. Consequently, agreements and regulations began to be developed and the scientific community carried out studies focused on what was already beginning to be known as the socio-environmental crisis. In this regard, different tools and strategies to integrate the three dimensions of sustainability or sustainable development, i.e., environmental, economic, and social, into decision making were proposed. The Social Life Cycle Analysis (S-LCA) is one of them [1–4].

Bruntland's report [5] defined sustainable development (SD) as "development that meets the need for the present without compromising the ability of future generations to meet their own needs". Since then, a very prolific discussion has occurred around a concept that condenses the most urgent goals for the next decades [6–8].

During the 1990s, the concept of the life cycle was created as a robust method to assess the environmental impacts of products throughout their entire life.

The first methodology to be developed was the Environmental Life Cycle Analysis, also known as Life Cycle Assessment (LCA), and is understood as the collection and evaluation of the inputs, outputs and potential environmental impacts of a system or product throughout its life cycle (UNE-EN ISO 14040) (The ISO 14040 Life Cycle Assessment standard regulates the environmental assessment methodology of life cycle analysis of a

product, analyzing and quantifying the environmental aspects and potential impacts of a product or service throughout its life cycle).

However, it did not take long to recognize the need to also analyze social and economic impacts, as these are closely related to environmental impacts. This would not be a simple task since the inclusion of social aspects in sustainability analyses has always been a challenge for experts of all kinds. This is when S-LCA came into play.

LCA (Life Cycle Assessment) and S-LCA (Social Life Cycle Assessment) are both methods used to assess the environmental and social impacts of products, processes, or services, but they focus on different aspects and have distinct goals [9,10]:

Life Cycle Assessment (LCA) primarily evaluates the environmental impacts of a product, process, or service throughout its entire life cycle, from raw material extraction to disposal or recycling. LCA considers factors such as energy consumption, resource use, greenhouse gas emissions, water usage, and other environmental indicators. It provides a comprehensive view of how a product or process affects the environment. The main goal of LCA is to identify areas where improvements can be made to reduce the environmental footprint of a product or process. It helps in making informed decisions about sustainability and reducing environmental impacts.

Social Life Cycle Assessment (S-LCA) focuses on the social and human rights aspects of a product, process, or service. It assesses the social impacts associated with its life cycle stages, including production, use, and disposal. S-LCA considers factors such as labor conditions, worker safety, community well-being, human rights violations, and other social aspects. It aims to identify and address social risks and opportunities within the life cycle. The main goal of S-LCA is to improve the social sustainability of products and processes. It helps organizations and stakeholders understand and manage the social impacts, ethical concerns, and labor practices associated with their products or services.

In summary, LCA primarily focuses on environmental aspects and helps in assessing the ecological footprint, while S-LCA focuses on social aspects and helps in evaluating the social footprint of a product or process.

When considering the historical evolution of S-LCA methodology, four fundamental stages can be distinguished: the first steps (1996–2009), the years of uncertainty (2009–2012), the years of development (2013–2016), and the quest for standardization (2017 onwards).

Today S-LCA is defined as a set of methods that seeks to examine the social impacts, both actual and potential, of a product or service. Such social impacts are understood as impacts to human capital, people's well-being, cultural heritage, or social behaviors.

At present, new ideas for indicators to be included continue to emerge and there is still a long way to go before the S-LCA becomes a consolidated tool.

In summary, S-LCA is a tool that supports decision making related to a certain product or a family of products. The analysis provides information on social and socio-economic aspects throughout the different stages of its life. An S-LCA is considered relevant when there is a relationship between what is to be analyzed or the questions to be answered and the social impacts related to the product. It can be very useful when deciding between alternatives. It may happen that one alternative is not necessarily better than the other from an environmental point of view, but the S-LCA might help to see a wider range of circumstances and consequences that make one of the two alternatives preferable. The tool also helps detect social challenges that may otherwise remain unseen.

It is common for this analysis to go hand in hand with other techniques or tools, for example, with an Environmental Life Cycle Analysis or a Life Cycle Cost Analysis, both of which are widely used. In cases where this is true, special attention should be paid to the system boundaries and the sources of information used so that there is a certain consistency between the different processes. It should be noted that consistency does not imply that these parameters must be identical, but rather that no major contradictions occur. The same applies to the results, where overlaps, coming from a partially shared methodology, should be avoided.

As mentioned above, the S-LCA is still in a preliminary stage compared to the LCA. Both share many characteristics since both are based on the analysis of the different impacts of a product or service from its creation to its destruction. It should be noted, however, that social stakeholders play a much more important role in the S-LCA than in its environmental counterpart.

Thus, in the present study we applied this S-LCA technique to the case study of greenhouse tomato production in Almeria (Spain). The main objective was to identify the main challenges to which day laborers, mainly migrant workers, are exposed, because of the precarious labor conditions in which they find themselves. Since tomato requires a very simple and common cultivation system, the results obtained in this project might be extrapolated to other types of vegetables and even to other similar production systems that do not require skilled laborers, both within Spain and abroad.

The province of Almeria had always been considered a desert where cultivation was extremely difficult to carry out. However, from the beginning of the 1960s, agriculture under plastics began to be developed as an alternative. This was a great revolution, mainly due to the reduction in costs compared to the traditional methods known up to that time.

Over the years, and due to the numerous advances that this sector has experienced, the number of greenhouses in the province has increased significantly.

In the 2021/22 season, production of fruits and vegetables in the region reached 3,823,359 tons, out of which 3,561,056 tons corresponded to production under plastic (93.1%) [11].

Export figures illustrate the importance of the industry for Almeria. In the same season, these reached a total of 2,864,211 tons of, with a value of EUR 3701.5 million. In 2020, this activity accounted for 13% of the provincial GDP. By adding handling, marketing and other industries related to agricultural production, this figure increases to 40% [12].

In general, the greenhouses located in this area are small, so the entrepreneur in charge of them is in many cases also a farmer, in most cases with low academic training. Traditionally, additional labor used to come mainly from the family. However, in recent decades there have been significant changes due to various reasons, such as the movement of relatives to the cities or the increase in the schooling periods of the youngest members. As a result, the sector has been forced to hire salaried workers on a temporary basis to meet its needs. Tomato is one of the most widely grown foods in the world, a production that has experienced significant growth since the beginning of the 21st century [13]. In turn, Spain is one of the countries that produces the most, achieving more than 30,000 million kilos per year. Within the country, Andalusia is the autonomous community with the highest volume, reaching 1716.7 thousand tons in 2020 [14].

Greenhouse vegetable production, particularly tomato production in Almeria, has many sustainability challenges. In addition to the generation of biomass waste, plastic materials, and water consumption, one of the most controversial aspects is the hosting of seasonal workers [15,16].

To date, the conditions of this type of worker are still far from being as regulated as in other sectors. Over the years, numerous amendments have been made to the relevant laws, the latest being contained in Royal Decree-Law 32/2021 on urgent measures for labor reform, the guarantee of employment stability, and the transformation of the labor market, to solve the problems due to excessive temporality in this labor market. However, these laws continue to be non-specific and do not address many other issues of the industry.

In the province of Almería, tomato is the main irrigated herbaceous crop, exceeding 2023 hectares [17]. The number of seasonal workers in the region reached 74,051 in 2021, of which almost half were foreigners.

Since their beginnings, the companies in this sector have been small and owned by local families. Due to various factors, such as globalization and increased quality controls, total production costs have increased over the years. The main issue that has led to this situation is the fact that, traditionally, additional labor came from the family sphere. However, in recent decades, there have been significant changes due to diverse reasons,

such as the migration of relatives to cities or the increase in schooling age for younger members. As a result, the sector has been forced to hire temporary wage workers to meet its needs.

Today, greenhouses in Almeria occupy a total of 31,614 hectares, the highest concentration in the world. This province is home to 87.4% of the total number of greenhouses in eastern Andalusia (Almeria, Granada, and Malaga) [18].

Most companies producing fruit and vegetables under plastic in this region are part of agricultural cooperatives. These are made up of several farmer-members who share the objective of making the best possible use of the cooperative's land in a democratic way, and work in a similar way to other agricultural cooperatives in other countries. It is normal that they share resources such as land, machinery, water, and knowledge to maximize efficiency and production quality.

In addition, the products are often marketed jointly afterwards. This not only lowers the total costs for the individual farmer, but also gives the local community greater bargaining power with respect to customers and suppliers [19]. The income generated from the sale of products is shared among its members according to their contribution or production.

Additionally, part of the profits is normally used to improve the facilities, technology, and services offered by the cooperative. Many of these agricultural cooperatives provide their members with technical training, agricultural advice, and access to innovations in the industry.

In 2015, more than 70 agricultural cooperatives were accounted for in this province alone, with a turnover of EUR 1.3 billion [20].

Cooperatives can be classified into four groups based on their size [21].

- Large cooperatives: Employ more than 250 people and have an annual turnover exceeding EUR 50 million. These are the least common, representing only 5% of the total cooperatives in Spain.
- Medium-sized cooperatives: Have between 50 and 250 employees and generate annual revenues ranging from EUR 2–10 million.
- Small cooperatives: Employ between 10 and 50 workers and have an annual turnover between EUR 2–10 million.
- Micro-cooperatives: Include the majority (41% of the national total), primarily consisting of local family businesses. They have fewer than 10 employees, and their turnover does not exceed EUR 2 million.

However, like in the rest of the country, the majority are classified as micro-cooperatives. In 2021, there were 14,500 families managing all the greenhouses in the provinces of Almeria and Granada, with an average of 2.3 hectares per family [22].

The cooperatives relevant to the case study are composed of several greenhouses, among other additional industries necessary for the complete production of fruits and vegetables. Each of them hires a certain number of seasonal workers each year, depending on their needs. However, many of these workers, especially migrant workers, are moved from one greenhouse to another according to seasonal needs. Also, the informal nature of the hiring process in many cases and the short-term duration of the "contacts" make it extremely difficult to determine how many employees are working in a greenhouse at any given time.

The conditions to which these people are exposed have been under scrutiny for many years as being far from appropriate. For this reason, the present study aims to analyze them in context to understand the severity of these conditions and to study future potential improvements.

2. Materials and Methods

As said, the S-LCA is a tool that serves as support in decision-making related to a specific product or a family of products. This analysis provides information about the social and socioeconomic aspects throughout the different life stages.

There are two ways to conduct the analysis, i.e., the Reference Scale approach (also known as Type I) and the Impact Pathway approach (also known as Type II), depending on the objectives of the study [23–25]. If the main objective is to describe the production system, focusing on its social development or risk, it is recommended to use the Reference Scale approach. If the goal is to predict the consequences of the production system, with an emphasis on characterizing potential social impacts, the Impact Pathway approach is preferable. As, in this case, the aim was to investigate the social aspects related to tomato production, specifically those that affect workers during the cultivation phase, in order to assess the size and significance of the social impacts present, it was deemed appropriate to use the Reference Scale approach.

2.1. Goal and Scope of the Study

The main goal of this study was to investigate, from various perspectives, the effects that working in the greenhouses of Almería has on the employees of these facilities, notably immigrants.

The functional unit in this study is 10 kg of harvested tomatoes. The main reason for this choice is that it is estimated to be the average amount that can be obtained from a plant in this environment per harvest, which typically lasts about 4 months.

Since this is a study of social nature, it is complicated and insufficient to provide all the data quantitatively. For this reason, qualitative data has also been used, which has not been directly linked to the functional unit but has still been considered relevant for the present case study.

2.2. System Boundaries and Assumptions

The system of this project is composed of greenhouse agriculture in the province of Almería, Spain. Specifically, it focuses on tomato production. The social impact of this production will be analysed from three different perspectives:

(i) General working conditions within the greenhouses
(ii) Legislation and trade unions
(iii) Use of fertilizers and health effects.

Additionally, the specific case of immigrant workers will be studied, as they are commonly present in the Spanish agricultural sector, particularly in Almeria. Furthermore, temporal limits must be considered. Since the analysis is based exclusively on previously published literature, this will determine the temporal scope of the investigation. Therefore, the study covers aspects relevant to the aforementioned sections over the last two decades (2003–2023). The context of intensive greenhouse agriculture in Almeria is broad and presents various interesting features that could be analysed. However, given the temporal limitation, the present study has focused on the three previously mentioned categories.

The United Nations Environmental Programme (UNEP) proposes a wide range of impact categories that can be assessed through an S-LCA [26]. However, not all of them are relevant to the case study in question, and therefore, only three of them were selected [27] as follows. (1) Fair Wage: It refers to a salary that is in line with the work performed and the amount of time spent, as well as within the minimums stipulated by law. (2) Safety and Health: This concept has been defined by various organizations on multiple occasions, and they all agree that every worker has the right to minimum conditions of safety and health in their workplace. This category aims to identify the number of incidents related to safety and health, as well as the level of prevention and management of such incidents. (3) Freedom of Association: Every employee has the right to create or join organizations that promote and defend their interests in relation to their work, without needing any prior permission from their employer. The analysis of this category seeks to determine the freedom granted by organizations to their employees to associate, as well as the importance placed on such associations. Although there are other relevant categories for the case study, they have been excluded from the analysis due to a lack of access to the necessary data, time constraints, or resource limitations.

2.3. Inventory

Due to the nature of the study and the available resources, it was decided to focus the work on secondary and generic data. Although clear standards regarding data quality in S-LCA have not yet been established, the UNEP Guidelines provide three criteria to guide the process [28]. These are: reliability, validity, and objectivity. The three of them were considered.

Various types of literature were consulted and studied, such as articles, reports, and other life cycle analyses. Sources came from different organizations, including government administrations, NGOs, universities, and research centers relevant to the investigation. Additionally, statistical data of different kinds were used regarding workers in the Almería agricultural sector.

3. Results

The main results of the analysis are presented below. First, the results obtained in relation to the functional unit are shown. Subsequently, an integrated study of the three categories analyzed is presented.

3.1. Relationship between Data and Functional Unit

To connect the obtained data more accurately with the selected impact categories, we linked the inventory directly with the previously determined functional unit, whenever possible.

Tomato plants require a significant amount of continuous work. Some of the activities involved include pruning, pollinating, and spraying of necessary agrochemicals. All of this implies that the amount of time dedicated to each plant is high, averaging 20 h per week per worker in a greenhouse [29].

It is worth noting that this time varies depending on the time of year, being higher during transplanting and harvesting seasons, and lower during periods when the plants are growing.

Most greenhouses fall into one of these two groups:

- 24 × 96 feet (7 × 29 m) greenhouse → 460–576 plants
- 30 × 96 feet (9 × 29 m) greenhouse → 576–720 plants

Most cooperatives in the Almeria region have greenhouses of approximately 9 × 29 m, so it can be estimated that they have around 600 plants. This implies that they produce a total of about 6000 kg of tomatoes. The following equations aim to calculate, through different values, the proportion of the total cost of the analyzed product which is absorbed by the labor cost. In addition, the main goal of this section is to compare the wage paid to temporary workers in Almeria with the minimum wage per hour established by law.

This will be carried out by calculating first the total number of hours required to take care of all the plants in an average greenhouse, followed by the labor cost per kg of tomato and comparing this last figure with the final price of tomatoes on the market.

$$600 \text{ plants} \times 20 \frac{\text{hours}}{\text{week}} = 12,000 \frac{\text{hours}}{\text{week}} \quad (1)$$

To take care of 600 tomato plants, an average of 12,000 h per week is required.

Each workday in the greenhouses has a variable duration, although it usually takes place between 6 am to 8 pm, which makes a total of 14 working hours [30]. The salary for a full 14 h workday ranges between EUR 30–35. This means that, to harvest the equivalent of 10 kg of tomatoes in a week (i.e., one plant), an employee would have to dedicate 20 h, which is almost one and a half workdays. This only happens on some occasions, as not all workers are chosen to work every day. The number of hired workers varies daily based on the needs and the capital available to the employers.

$$6000\left[\frac{\text{kg tomato}}{\text{greenhouse}}\right] \times \frac{1}{8}\left[\frac{\text{season}}{\text{weeks}}\right] \times \frac{1}{20}\left[\frac{\text{week}}{\text{hours}}\right] \times \frac{14}{33}\left[\frac{\text{hours}}{€}\right] = 15.9\left[\frac{\text{kg}}{€}\right] \rightarrow 0.063\left[\frac{€}{\text{kg}}\right] \quad (2)$$

Equation (2) shows that the cost solely of labor within tomato greenhouses is EUR 0.063 per kg of product. In Spain, the retailing price of 1 kg of tomatoes ranges from EUR 1.5–2 per kilogram.

$$\frac{0.063}{1.75} \times 100 = 3.6\% \quad (3)$$

This implies that the cost of labor represents 3.6% of the total price of tomatoes in the market.

According to Article 1 of Royal Decree 99/2023 (14 February), the minimum wage in Spain corresponds to EUR 36 per day for an 8 h workday. Article 4 of the same document establishes that the minimum wage for temporary and seasonal workers is EUR 8.45 per hour. The hourly compensation for workers in the greenhouses varies as not all individuals receive the same wage, but an approximation can be calculated.

$$\frac{33\,€}{14\text{ hours}} = 2.35\frac{€}{\text{hours}} \quad (4)$$

This value is well below the legal minimum, just like the amount of time temporary workers are required to work each day. The analysis highlights the severity of the conditions regarding wages in the greenhouses of Almeria.

3.2. Integrated Analysis

To allow for the joint visualization of the three selected impact categories, a radial chart was developed. For this purpose, five levels were established. Level 1 represents a category that is not only misaligned with the work performed and the time dedicated to it but also significantly fails to meet the minimum legal standards, whereas Level 5 corresponds to a category that appropriately aligns with the work performed and the time spent, being the only one meeting the minimum requirements set by current legislation.

Applying these levels to the salary (see Table 1), workers in the greenhouses receive, as calculated in the previous point, a salary of EUR 2.35 per hour is obtained. This value falls between level 1 and level 2, but very close to the former. Consequently, it was established that the current salary falls into level 1 of the scale.

Table 1. Numeric salary scale.

Level	Proportion with Respect to Minimum Legal Salary	Equivalent Salary per Hour
1	25%	EUR 2.11
2	45%	EUR 3.80
3	65%	EUR 5.49
4	85%	EUR 7.18
5	100%	EUR 8.45

To assign a level to the impact category "health and security", an analysis regarding the use of fertilizers and pesticides was carried out. These substances contain various ingredients, many of which are considered dangerous to human health. For example, carbon tetrachloride and chloroform have been proven to be toxic to the liver and the central nervous system, among others [31].

The regulations regarding the manufacturing, storage, trade, waste management, and use of pesticides were stated in the Spanish legislation, namely Royal Decree 443/1994. This was later updated by Royal Decree 1311/2012 on the sustainable use of healthcare products,

complementing the latter with essential requirements for handling these substances. This legislation is subject to the common regulations established by the European Union for all member countries and must always be adapted accordingly. In spite of this, in the previous years, Spain increased its investment in pesticides [32].

As previously mentioned, plastic-covered cultivation has numerous advantages that benefit the sector. However, factors such as high temperatures, high humidity, and poor air circulation also promote the spread of parasites. Therefore, the use of pesticides is higher than in other cultivation systems. Additionally, these conditions exacerbate the toxicity of the substances present in the pesticides [33]. As a result, pesticides have severe consequences on the health of greenhouse workers, as well as their families and neighbors, as they often live in the greenhouses themselves.

Despite there being more control over the use of pesticides in the agricultural sector, Almeria is the Andalusian province with the highest number of acute pesticide poisonings (ACP). Between 2007 and 2017, total ACP in the Andalusian regions ranged from 3 cases in Malaga to 13 in Cordoba. Almeria's values were more almost 20 times higher, reaching a total of 255 poisonings in the decade [24]. This is consistent with the fact that Almeria has the highest number of greenhouses in the region. It is worth noting that most greenhouse workers, especially temporary ones, have not received any training on how to safely apply these products [34]. Furthermore, it is also common for them to lack appropriate protective equipment such as personal protective equipment (PPE) or even just gloves, thus systematically disregarding the Occupational Risk Prevention Law 31/1995. Abdelkader Cacha, spokesperson for the Union of Field Workers, reports that employees "do not have masks or protective clothing", and that "those who request them are forced to leave" [35].

The effects of this type of poisoning are multiple, ranging from dermatitis, diarrhea, and vomiting to a decrease in heart rate that can lead to death [36].

Although most cases last only a few days, many of them result in lingering symptoms such as fatigue and respiratory difficulty. Moreover, even to this day, there are cases of deaths, mainly among immigrants residing in the vicinity or within the greenhouses [37].

In addition, the fact that the exact number of temporary workers in these facilities is not known makes it very difficult to determine the degree and effects of the exposure to these chemicals [33].

After the evaluation of all the compiled information, it is concluded that the impact category "health and security" falls into level 1.

Let us now analyze the third impact category studied, i.e., the right to freedom of association (included in the Fundamental Rights enshrined in the Spanish Constitution). According to this right, every worker is free to create or join a labor union that protects and assists them with work-related matters.

However, this right is reserved for those who work in legal conditions. This excludes undocumented immigrants (without residence or work permits) and workers without contracts, two extremely common profiles in the Almeria's greenhouses. Additionally, many of the foreign employees are not integrated into Spanish society, leading to a lack of awareness about the rights they are entitled to. This exacerbates the situation and results in significantly lower rates of unionization compared to other regions and industries in Spain [30].

The unions started to address this situation when, despite being one of the largest and most profitable agricultural industries in Spain, the unemployment rate and living conditions in the Almeria region were much worse than in other places. During the horticultural campaign in April 2021, unemployment in Almeria increased by 3.12%, while it decreased in the rest of Spain [38]. This surprised the major unions and revealed the substantial size of the underground economy in this area.

A study conducted by the labor union *Comisiones Obreras* (CCOO) revealed that in the 2019–2020 campaign, companies in the sector paid a total of EUR 45 million less in Social Security contributions for employees compared to previous campaigns. This led to the belief that illegal hiring had experienced a significant increase.

It is important to note that the agriculture sector in the province of Almeria has been without a labor agreement since 2015, mainly due to employers' refusal to negotiate. In such cases, the law states that the sector should follow the workers' statute, which requires paying at least the minimum wage to all employees. However, in practice, these are general laws that often leave legal loopholes that employers take advantage of to evade compliance.

One of the main problems that leads to this situation is the overwhelming number of greenhouses in the region, covering thousands of hectares, which makes proper inspection extremely challenging. Additionally, illegal workers are often hidden by employers.

The study of this scenario concludes that the impact category "Freedom of Association" could be classified in level 2 of the aforementioned scale. Nevertheless, further analyses should be developed to provide a more robust decision in this regard.

Table 2 shows the value assigned to the three impact categories, along with its description.

Table 2. Assignment of a numerical value to each analyzed impact category.

Impact Category	Value	Description
Fair salary	1	Workers receive a salary much lower than the legal minimum (based on previous calculations). Additionally, they are required to work for, in many cases, 14 consecutive hours, which is problematic, especially in jobs involving manual tasks, such as those carried out in greenhouses.
Health and security	1	Workers do not receive any information regarding safety in their workplace, which is considered highly dangerous due to the physical conditions present in the greenhouses and the use of toxic substances. In many cases, they are not provided with adequate protective equipment, which has resulted in numerous accidents and illnesses for both the workers and their families. There have even been reported cases of deaths resulting from these negligences.
Free association	2	In this sector, the fundamental right of free association, as established by Spanish law, is not respected due to the large number of workers in the greenhouses who lack employment contracts. These employees are not provided with any information about their rights, which also prevents them from asserting their rights as they are unaware of their existence. As mentioned earlier, since 2015, the province of Almería has lacked a labor agreement that serves as a regulatory framework in this area. It is also worth noting that 95% of the contracts in 2020 were temporary, while only 5% were permanent. No reliable data on the total number of workers without a contract have been collected. If this is very high (which is quite plausible), the value assigned to this variable could well be reduced to 1.

Based on this data, a corresponding radial graph is shown below.

Figure 1 shows a radar chart including the three indicators.

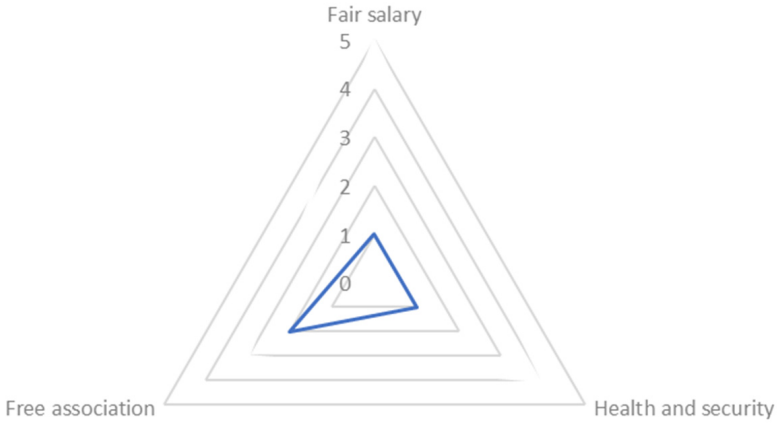

Figure 1. Perspective of impact categories in a radar chart. 0 represents worst performance.

It is essential to highlight the fact that, given that this analysis is primarily qualitative, these results can be subject to interpretation. To draw more precise conclusions, it would be necessary to carry out an additional quantitative analysis.

4. Discussion

Unlike traditional Life Cycle Assessment, in an S-LCA the results are not as direct and precise. Since its inventory is primarily based on social and human factors, the information, in many cases, cannot be objectively quantified and is open to interpretation. However, certain aspects can be inferred from the compiled inventory.

As previously stated, the objective of this analysis was to relate all the gathered information to the impact categories of fair wages, freedom of association, and health and safety. After conducting appropriate calculations and comparing them with Spanish standards, it can be concluded that temporary workers in Almeria's greenhouses do not have fair wages or any labor guarantees. This raises concerns about wage fairness and equity in the tomato greenhouse industry and suggests the need to examine and address this issue from the perspective of fair wages.

For several years, immigrants have played a crucial role in the agricultural economy of Almeria like in many other regions [39–44]. Although these workers perform tasks that were previously carried out by Spaniards, their working conditions are often inferior. Immigrants are typically hired for temporary jobs, while stable employment is reserved for Spanish workers.

In addition to wages below the legally established minimum, most immigrants, many of whom are in an irregular situation, face endless workdays, physical and psychological abuse, and some live in the greenhouses themselves without access to basic services such as clean water or electricity. The physical characteristics of the greenhouses allow for efficient year-round crop cultivation. However, these favorable conditions for the plants put the health and safety of the workers at risk.

The gathered information shows that the working conditions in the greenhouses are truly extreme. Both the long working hours with little or no rest, as well as high temperatures and lack of hygiene and protection, endanger the health and safety of these workers.

Moreover, the incorrect use of pesticides poses a significant risk not only to the workers themselves but also to their families and people living near the greenhouses. In the case of immigrant workers, the lack of access to basic healthcare services due to their irregular status leaves them in an extremely vulnerable situation regarding these problems.

It is important to note that, despite the growing regulations in Spain and the European Union regarding the use of pesticides and their derivatives, their usage remains high in the Almeria region, which is the province with the highest number of greenhouses in Andalusia. This poses a serious problem for the health of the workers, as there is a lack of training and adequate protective equipment.

Regarding freedom of association, a fundamental right in Spain across all sectors, this analysis reveals that its application in the agricultural industry, particularly in the Almeria region, is largely limited by two factors: the presence of undocumented immigrant workers and the underground economy. The main mitigating factor of this situation is the workers' lack of knowledge about their rights, as well as the absence of specific labor agreements for the agricultural sector. In general, the combination of irregular status, unsafe work conditions, and lack of health care has been pointed out as a social risk by other authors, in the context of other crops elsewhere across the world.

It can be concluded that the lack of action by authorities and the employers' refusal to negotiate a collective agreement contribute to maintaining precarious working conditions.

What stands out in this study is that despite all these unfavorable conditions, the demand for work remains high, especially among foreigners. This is due to the lack of employment opportunities and the urgent need these individuals have to find work, which leads them to accept extremely precarious conditions. Spain is often the first European

country that African immigrants reach, and many of them seek employment in agriculture to regularize their immigration status.

As noted above, the main limitation of the study is centered on the methodology used based on bibliographic references. In addition, the information found was very limited due to the complexity of the case. Future work will seek to complement the current study with a field study to cover these shortcomings and provide even more robust results.

5. Conclusions

Greenhouse tomato production in Almeria heavily relies on the workforce of immigrant workers, who are hired under dire conditions, mainly due to their irregular residence status in Spain. Companies hiring them are typically small-scale family run cooperatives, with little capacity to offer better conditions, The workload typically exceeds the average 8 h workday, and salaries are well below the minimum established by law. Hiring is irregular and on a temporary basis, preventing these workers from having any financial security, save income, and being unable to access adequate health care or even housing and food, forcing them to live in the greenhouses themselves. Work conditions in the greenhouses are hard, due to exposure to agrochemicals, heat, and long working hours. In addition, exposure to agrochemicals is high and has long-term effects on worker's and bystander's health, an effect further aggravated by the denial of managers and foremen to provide protective equipment and training. This has even resulted in the demise of some workers. The lack of information and of the opportunity to join unions, trade associations, or even migrant rights NGOs prevents them from improving these conditions. The language and cultural barriers generate further difficulties in providing training and claiming rights by the workers themselves. Despite the difficulties obtaining accurate data about immigrant workers in tomato greenhouses in Almería, this contribution has shed light on the social challenges faced by these workers and hopefully may contribute to stimulate the discussion around the ethical aspects of tomato growing in Spain.

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References

1. Ramos Huarachi, D.A.; Piekarski, C.M.; Puglieri, F.N.; de Francisco, A.C. Past and Future of Social Life Cycle Assessment: Historical Evolution and Research Trends. *J. Clean. Prod.* **2020**, *264*, 121506. [CrossRef]
2. Moltesen, A.; Bonou, A.; Wangel, A.; Bozhilova-Kisheva, K.P. Social Life Cycle Assessment: An Introduction. In *Life Cycle Assessment*; Springer: Cham, Switzerland, 2017; pp. 401–422. [CrossRef]
3. Petti, L.; Serreli, M.; Di Cesare, S. Systematic Literature Review in Social Life Cycle Assessment. *Int. J. Life Cycle Assess.* **2018**, *23*, 422–431. [CrossRef]
4. Wu, R.; Yang, D.; Chen, J. Social Life Cycle Assessment Revisited. *Sustainability* **2014**, *6*, 4200–4226. [CrossRef]
5. Keeble, B.R. The Brundtland Report: 'Our Common Future'. *Med. War* **2007**, *4*, 17–25. [CrossRef]
6. Mensah, J. Sustainable Development: Meaning, History, Principles, Pillars, and Implications for Human Action: Literature Review. *Cogent Soc. Sci.* **2019**, *5*, 1653531. [CrossRef]
7. Manioudis, M.; Meramveliotakis, G. Broad Strokes towards a Grand Theory in the Analysis of Sustainable Development: A Return to the Classical Political Economy. *New Political Econ.* **2022**, *27*, 866–878. [CrossRef]
8. Klarin, T. The Concept of Sustainable Development: From Its Beginning to the Contemporary Issues. *Zagreb Int. Rev. Econ. Bus.* **2018**, *21*, 67–94. [CrossRef]

9. Zamagni, A.; Zanchi, L.; Cesare, S.D.; Silveri, F.; Petti, L. Theory and Practice on Social Life Cycle Assessment. In *Life Cycle Engineering and Management of Products*; Springer: Cham, Switzerland, 2021; pp. 143–168. [CrossRef]
10. Toniolo, S.; Tosato, R.C.; Gambaro, F.; Ren, J. Life Cycle Thinking Tools: Life Cycle Assessment, Life Cycle Costing and Social Life Cycle Assessment. In *Life Cycle Sustainability Assessment for Decision-Making*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 39–56. [CrossRef]
11. Cajamar Informe Cajamar Detalla Todas Las Cifras de La Agricultura Almeriense. Available online: https://agroautentico.com/2022/11/informe-cajamar-resume-todas-las-cifras-de-la-agricultura-almeriense/ (accessed on 7 September 2023).
12. Sotomayor Martínez, J.A. Invernaderos: Agricultura Bajo Plástico En Almería-Sembralia. Available online: https://sembralia.com/blogs/blog/invernadero-almeria-plastico-industria (accessed on 20 July 2023).
13. Hueso-Kortekaas, K.; Romero, J.C.; González-Felipe, R.; Bergman, M. Energy-Environmental Impact Assessment of Greenhouse Grown Tomato: A Case Study in Almeria (Spain). *World* **2021**, *2*, 425–441. [CrossRef]
14. Statista Tomates: Producción Por Autonomías En España En 2021 | Statista. Available online: https://es.statista.com/estadisticas/510892/produccion-de-tomates-en-espana-por-comunidad-autonoma/ (accessed on 20 July 2023).
15. Archontakis, F.; Anastasiadis, F. Technology and Innovation in Southern Europe's Agri-Food Sector: A Delphi Study. *Int. J. Technol. Manag. Sustain. Dev.* **2019**, *18*, 17–36. [CrossRef] [PubMed]
16. Piezer, K.; Petit-Boix, A.; Sanjuan-Delmás, D.; Briese, E.; Celik, I.; Rieradevall, J.; Gabarrell, X.; Josa, A.; Apul, D. Ecological Network Analysis of Growing Tomatoes in an Urban Rooftop Greenhouse. *Sci. Total Environ.* **2019**, *651*, 1495–1504. [CrossRef] [PubMed]
17. Instituto de Estadística y Cartografía de Andalucía Instituto de Estadística y Cartografía de Andalucía. Available online: https://www.juntadeandalucia.es/institutodeestadisticaycartografia (accessed on 20 July 2023).
18. Criado & Lopez Récord En Superficie de Invernaderos de Almería, 31.614 Hectáreas, Mayor Concentración Mundial. Available online: https://criadoylopez.com/record-en-superficie-de-invernaderos-de-almeria-31-614-hectareas-mayor-concentracion-mundial/ (accessed on 20 July 2023).
19. Payán López, I.C. Revisión Bibliográfica de Las Cooperativas Agrarias En Almería. 2014. Available online: http://repositorio.ual.es/handle/10835/2697?show=full (accessed on 20 July 2023).
20. Agricultura2000 Más de 70 Cooperativas Facturan Casi 1.300 Millones de Euros En Almería | La Voz de Almería. Available online: https://www.lavozdealmeria.com/agricultura2000/noticia/8/agricultura/86958/mas-de-70-cooperativas-facturan-casi-1-300-millones-de-euros-en-almeria (accessed on 7 September 2023).
21. AgroNews ¿Sabes Cuáles Son Las 20 Cooperativas Agrarias Que Más Facturan En España?—Agronews. Available online: https://www.agronewscastillayleon.com/sabes-cuales-son-las-20-cooperativas-agrarias-que-mas-facturan-en-espana/ (accessed on 7 September 2023).
22. Agroauténtico 110.000 Puestos de Trabajo Genera El Invernadero En Almería y Granada | Agroautentico.Com. Available online: https://agroautentico.com/2021/09/trabajo-en-invernaderos-almeria-y-granada/ (accessed on 7 September 2023).
23. Benoît, C.; Norris, G.A.; Valdivia, S.; Ciroth, A.; Moberg, A.; Bos, U.; Prakash, S.; Ugaya, C.; Beck, T. The Guidelines for Social Life Cycle Assessment of Products: Just in Time! *Int. J. Life Cycle Assess.* **2010**, *15*, 156–163. [CrossRef]
24. Jørgensen, A.; Finkbeiner, M.; Jørgensen, M.S.; Hauschild, M.Z. Defining the Baseline in Social Life Cycle Assessment. *Int. J. Life Cycle Assess.* **2010**, *15*, 376–384. [CrossRef]
25. Jørgensen, A.; Le Bocq, A.; Nazarkina, L.; Hauschild, M. Methodologies for Social Life Cycle Assessment. *Int. J. Life Cycle Assess.* **2008**, *13*, 96–103. [CrossRef]
26. U.N. Environment Programme. Guidelines for Social Life Cycle Assessment of Products and Organisations 2020. 2020. Available online: https://www.unep.org/resources/report/guidelines-social-life-cycle-assessment-products (accessed on 20 July 2023).
27. UNEP Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA) 2021—Life Cycle Initiative. Available online: https://www.lifecycleinitiative.org/library/methodological-sheets-for-subcategories-in-social-life-cycle-assessment-s-lca-2021/ (accessed on 20 July 2023).
28. Andrews, E. *Guidelines for Social Life Cycle Assessment of Products: Social and Socio-Economic LCA Guidelines Complementing Environmental LCA and Life Cycle*; UNEP/Earthprint: Nairobi, Kenya, 2009.
29. Richard, G.S. *Guía Del Cultivo Del Tomate En Invernaderos—Richard Glen Snyder*; Mississippi State University: Starkville, MS, USA, 2006.
30. Martínez Sanmamed, M. Problemas Laborales En La Agricultura Almeriense: El Caso de La Inmigración. 2021. Available online: https://uvadoc.uva.es/handle/10324/50959 (accessed on 20 July 2023).
31. Ruiz Esteban, A. Toxicidad Crónica Por Plaguicidas En Trabajadores de Invernadero de La Zona Básica de Salud de Níjar (Almería). Doctoral Dissertation, Universidad de Granada, Granada, Spain, 1998.
32. MAPA Anuario. Available online: https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/2021/default.aspx (accessed on 20 July 2023).
33. Alarcón Rodríguez, R. Criptorquidias y Xenoestrogenicidad Por Pesticidas En La Provincia de Almería. Ph.D. Thesis, Universidad de Granada, Granada, Spain, 2004.
34. Matkin, E. Invernaderos: La Búsqueda Por El Trabajo Estable y Seguro y Un Medioambiente En Peligro. *Independent Study Project (ISP) Collection*. 2010. Available online: https://digitalcollections.sit.edu/cgi/viewcontent.cgi?article=2234&context=isp_collection (accessed on 20 July 2023).

35. Leidle, S. Ilegales En España: Esperanzas Ahogadas En Un Mar de Plástico—DW—12/04/2007. Available online: https://www.dw.com/es/ilegales-en-espa~na-esperanzas-ahogadas-en-un-mar-de-plastico/a-2440937 (accessed on 20 July 2023).
36. Ferrer, A. Intoxicación Por Plaguicidas. *An. Sist. Sanit. Navar.* **2003**, *26*, 155–171. [CrossRef] [PubMed]
37. ABC Investigan La Muerte Por Intoxicación de Un Inmigrante En Un Invernadero de Almería. Available online: https://sevilla.abc.es/andalucia/almeria/sevi-investigan-muerte-intoxicacion-inmigrante-invernadero-almeria-201901291543_noticia.html (accessed on 20 July 2023).
38. Publico La Paradoja de Almería: La Agricultura de Invernadero Más Potente En Los Pueblos Con La Renta Más Baja de España | Público. Available online: https://www.publico.es/economia/paradoja-almeria-agricultura-invernadero-potente-pueblos-renta-baja-espana.html (accessed on 21 July 2023).
39. Namany, S.; Govindan, R.; Alfagih, L.; McKay, G.; Al-Ansari, T. Sustainable Food Security Decision-Making: An Agent-Based Modelling Approach. *J. Clean. Prod.* **2020**, *255*, 120296. [CrossRef]
40. King, R.; Lulle, A.; Melossi, E. New Perspectives on the Agriculture–Migration Nexus. *J. Rural Stud.* **2021**, *85*, 52–58. [CrossRef]
41. Tagliacozzo, S.; Pisacane, L.; Kilkey, M. The Interplay between Structural and Systemic Vulnerability during the COVID-19 Pandemic: Migrant Agricultural Workers in Informal Settlements in Southern Italy. *J. Ethn. Migr. Stud.* **2020**, *47*, 1903–1921. [CrossRef]
42. Molinero-gerbeau, Y.; López-sala, A.; Șerban, M. On the Social Sustainability of Industrial Agriculture Dependent on Migrant Workers. Romanian Workers in Spain's Seasonal Agriculture. *Sustainability* **2021**, *13*, 1062. [CrossRef]
43. Jinkang, A. Contemporary Slavery: The Exploitation of Migrants in Italian Agriculture. 2020. Available online: https://dialnet.unirioja.es/servlet/tesis?codigo=292844 (accessed on 20 July 2023).
44. Rogaly, B. Commentary: Agricultural Racial Capitalism and Rural Migrant Workers. *J. Rural Stud.* **2021**, *88*, 527–531. [CrossRef]