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ENVIRONMENT IMPACT ASSESSMENT OF SOLID WASTES OF PESTICIDE INDUSTRY

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ABSTRACT

Life cycle impact assessment (also known as LCA) is a method that examines the output impacts of any manufacturing system in addition to providing a better understanding of the energy, water, and material inputs. LCA research has been conducted on a wide variety of crops and goods from all over the world. However, there are certain nations that have either none at all or very few studies. In this section, we report the findings of a literature study that was conducted in accordance with the PRISMA protocol to find out what work has been done in LCA to assist stakeholders in these areas in better comprehending the environmental impact that a product has during its various stages of production. In order to consolidate LCA research on agricultural operations, the published literature was investigated by using the Google Scholar database. A total of 74 papers were looked at for their findings. In order to get an understanding of the many different effect categories that are a part of LCA, the papers being reviewed are studied in great detail. According to the findings of the study, the principal crops taken into consideration for LCA were tomatoes and wheat. The primary emphasis was placed on the most significant environmental consequences, specifically the human toxicity potential and the terrestrial ecotoxicity potential. In addition, the CML, ISO, and IPCC impact methodologies were utilized the most frequently. It was also discovered that studies were carried out in Europe the majority of the time due to the fact that the majority of models and databases are designed to work with European agri-food goods. The literature review did not concentrate on a particular geographical area or type of crop. As a direct result of this, a significant number of studies came up when the keywords were searched for. Despite the aforementioned restrictions, this evaluation offers practitioners of LCA a helpful point of reference.

Keywords: *meta-analysis, GHG emission, ecotoxicity, agriculture*

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1. Introduction

Food supply chains, often known as FSCs, are notoriously convoluted. FSCs are made up of many different components that are responsible for the processing, production, packaging, storing, transferring, distributing, and marketing of food goods to final consumers. As is the case with any other supply chain, the FSC process has several critical components; if one of these components is altered, it has repercussions for the other components. When defining the Food System Cluster, various organizations and agencies, such as the Food and Agricultural Organization (FAO), the Institute of Medicine (IOM), and the National Research Council (NRC), note the connection that exists between the food system and the economy, the environment, and society. As a result, the question that needs to be answered most carefully is as follows: Which method of food production is better for both the environment and the community in terms of long-term viability?

worries regarding food resources and significant population increase include, amongst other things, the ability to meet the food demand of the world's population, as well as worries over food production and food consumption. To satisfy the needs of the growing global population by the year 2050, total food production will either need to more than double or expand by at least 70 percent. According to the results of several computer simulations, an increase in crop productivity of 2.4% per year is required to satisfy demand in 2050. The increased demand for food causes the food supply chain to utilize a significant amount of energy and resources, which in turn leads in a variety of adverse effects on the environment. The production of food is known to have a number of negative effects on the surrounding environment, such as the use of land and water and the acceleration of climate change. The primary causes of the significant environmental problems that humanity now faces are climate change and the anticipated scarcity of fossil fuels in the not-too-distant future. Agricultural practices, fertilizers, pesticides, the pumping of water, tractors used to prepare the land, and the transfer of crops or finished food products through railroads, trucks, airplanes, or ships are all examples of things that have the potential to have an impact on the environment. Last but not least, the practices of food processing and food preservation, such as refrigeration and packing, also contribute to the damage done to the environment. One of the numerous production sectors that contribute to environmental impacts is the agricultural sector. Other production sectors also contribute to environmental problems.

The Environmental Protection Agency (EPA) identifies the production of agricultural chemicals and pesticides as two of the 68 area source groups that are responsible for 90 percent of the total emissions of the 30 urban air pollutants. For instance, in the year 2018, the greenhouse gas (GHG) emissions produced by the agricultural industry amounted for 9.9% of the total greenhouse gas emissions in the United States. In addition, the amount of greenhouse gases produced by agriculture has increased by 10.1% since 1990. Nitrous oxide is considered to be one of the direct greenhouse gases. Nitrous oxide is produced as a byproduct of agricultural soil management practices. These practices include the use of synthetic and organic fertilizers, as well as other cropping methods, the management of manure, and the burning of agricultural waste. In the United States, agricultural soil

management is the primary contributor to N2O emissions, accounting for approximately 75% of the country's total emissions. For example, agricultural soils are a significant contributor to nitrogen oxides (NOx) pollution in the state of California; the Central Valley region of the state has particularly high levels of soil NOx emissions. As a result of this, it is vital to assess the consequences that agricultural goods have along the food supply chain in order to create production and consumption systems that are sustainable.

Because the number of processes involved in the food system is extensive and complicated, the life cycle assessment (LCA) approach has been employed in a great number of studies as a tool to investigate the overall resources that are utilized and the influence that food products have on the environment throughout their entire life cycle. It is most known for its qualitative and quantitative analysis of the environmental elements of a product over its entire life cycle. This aspect of its work has received the most attention. Both tangible items and intangible services might be considered products in this perspective. In the context of life cycle assessment (LCA), the term "environmental impacts" refers to the negative effects that a factor has on an area of interest, such as the ecosystem, human health, or natural resources. Since the 1960s, life cycle assessment (LCA) has been utilized to discover solutions for sustainable production in response to the growing scarcity of raw materials and energy supplies.

This type of research on the supply chain for crops can provide useful information from the perspectives of the economy, society, and the environment. Utilizing the LCA allows for a greater understanding of the inputs of energy, water, and materials, as well as an evaluation of the consequences caused by the outputs. As a result, decision-makers in a variety of industries are able to govern new regulations and make use of modern methods to strengthen industrial supply chains. Previous research has shown that several authors have made use of LCA in order to investigate the environmental consequences that crops have throughout their whole life cycles. However, the food supply chain, which is the largest industrial sector in the world, contains a wide variety of crops and products that have not yet been taken into account by the LCA.

As a result, the overarching goal of this study is to consolidate the LCA studies relating to the various environmental consequences caused by agricultural production in order to provide decision-making support to relevant stakeholders. In addition to that, a comprehensive study of the several steps that are involved in LCA is presented.

OBJECTIVES

1. To study solid wastes
2. To study environment impact assessment of solid wastes of pesticide industry

Materials and Methods

In order to fulfill the aims of the research, a literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedure. The review consisted of publications that had been published in international journals.

Eligibility Criteria

The studies that applied the following selection criteria were chosen to limit the number of articles: (i) using the LCA approach; (ii) include GHG in their impact category and/or ecotoxicity; and (iii) researching farm items. These three criteria were employed in order to narrow down the number of publications. There were a total of 36 research articles that were disregarded because they either focused on FSCs rather than GHG or ecotoxicity as an effect category, did not employ the LCA technique, or applied the LCA method to products other than agricultural produce. Extensive analysis was performed on the LCA studies, taking into consideration all four phases of the LCA:

- Goal and scope definition,
- Life cycle inventory,
- Life cycle impact assessment,
- Life cycle interpretation/recommendation options.

Search Strategy

The Google Scholar database was utilized in order to complete the literature review. In the first part of the process, the keyword "LCA crop production" was utilized, which resulted in the production of 59,100 studies as of July 2021. Later on, more precise terms such as "agri-food supply chain and LCA" and "agri-food supply chain and GHG" were used in conjunction with a variety of fruit and vegetable items such as corn, peanuts, wheat, tomato, and apple. However, the number of studies that are now available is still rather substantial. The most number of articles that we obtained when we used the aforementioned key term with various crops was 7330, and the least number of papers that we obtained was 1820. The total number of articles that were downloaded and examined was 110. Twenty-nine studies were disregarded either because to the fact that they focused on FSCs rather than GHGs or ecotoxicity as an effect category or because they made use of the LCA methodology.

In addition, seven more were omitted due to the fact that they used the LCA methodology to items that were not agricultural. Following the application of the selection criteria, the total number of articles that we were left with was 74. The procedures that were taken during the review are depicted in Figure 1, along with the criteria that were used to choose the relevant literature.

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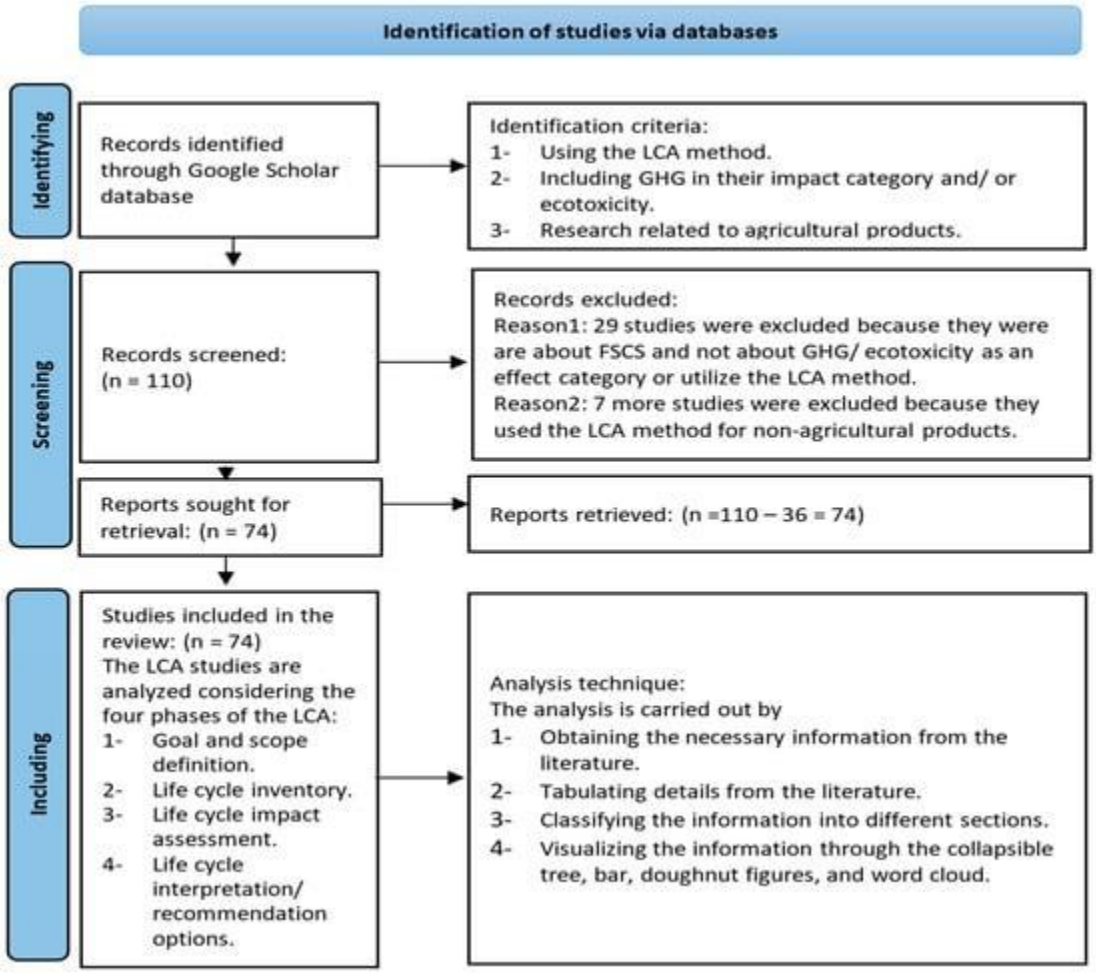

Figure 1 Steps followed for review and the inclusion/exclusion criteria.

Categorization

The year the study was conducted, the purpose of the study, and the many procedures involved in LCA evaluation were some of the pieces of information acquired from the papers that were evaluated and discussed in the section under "Results." There is discussion regarding the timing, the many components, the approach of the LCA, the application of the LCA idea in the impact analysis, and suggestions for a sustainable food system.

DATA ANALYSIS

The investigation was carried out by acquiring the required information from the relevant body of published research. After the information was separated into its several result sections, it was further represented through the use of collapsible trees, bar charts, doughnut figures, and word clouds. Word clouds are a method of text representation that has developed into an approach that is both

simple and pleasant to the eye. They are utilized in a wide variety of settings to provide an overview by condensing the text down to the terms that appear the most frequently. This is typically completed using statistical methods as a summary of the pure text. Word clouds can serve as the first stage in the process of refining the significant concepts that have emerged from the research. This might help future researchers save a significant amount of time because they would already be aware of where to begin as well as the most prevalent terms and concepts. The relationship of the parts to the whole can be visually shown using pie and doughnut charts. It is the purpose of collapsible trees, bar charts, and doughnut figures to present more numerical detail. The ability to convey qualitative and quantitative information on the findings of the LCA was made possible by combining bar charts with word clouds.

The bar and doughnut figures were crafted in Microsoft Excel, while the collapsible tree diagram was developed with R software Version 3.6.1. When creating word cloud figures with the help of the word cloud online website, it is essential that each word be written accurately because the amount of words submitted influences both the size and the color of the words that are displayed in the figure. As a result, it is absolutely necessary to double check that the quantity of words that you input is accurate.

In conclusion, the research was laid up using the IMRAD format, which is the format that is utilized the most frequently in scientific articles. The term is an acronym that stands for the initial letters of the terms "introduction," "materials and methods," "results," and "discussion." The IMRAD format makes the acquisition of knowledge easier and makes it possible to evaluate an item more quickly. At this time, IMRAD is being utilized by the vast majority of scholarly publications. Before the IMRAD format was implemented, all academic writing adhered to the IBC pattern, which consists of an introduction, main body, and conclusion. The sole difference between the IMRAD format and the IBC format is that the IMRAD format is more specific. It is essential to keep in mind that no magazine publishes articles in a format that is standardized or consistent across all of its articles. However, despite the fact that each journal has its own format, they all adhere to a standard set of guidelines for authors.

Results

Snapshot of Selected Studies

Figure 2 provides an overview of LCA research by displaying the features of papers that were published between the years 1998 and 2021. Since 2008, when the ISO standard was first developed, there has been a consistent growth in the total number of publications that are produced each year.

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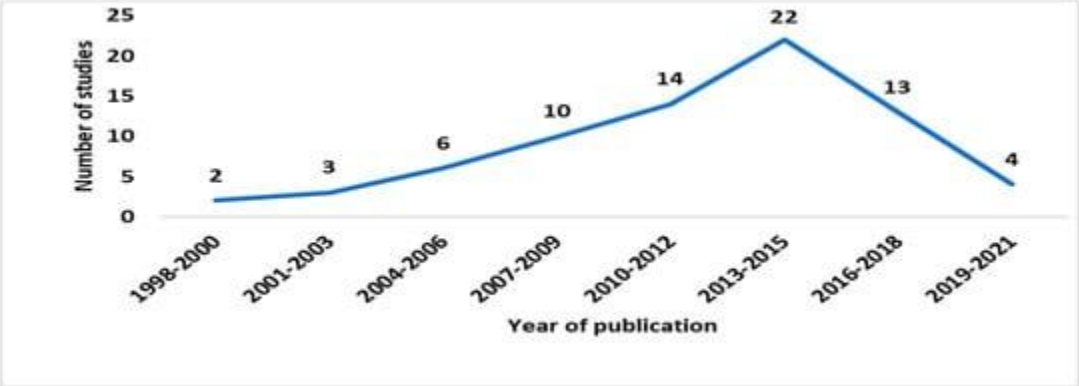

Figure 2. The number of studies that were conducted in relation to LCA of agricultural production between the years 1998 and 2021 (n = 74).

Prior to 2006, one of the primary criticisms leveled at the ISO 14040 series was the assertion that life cycle assessment (LCA) is still in its infancy and that ISO 14040 does not address uncertainty, weighing, valuation, or allocation.

It was in 2006 when the most recent revision of the ISO 14040 standard was made available, which explains why more emphasis is being paid to LCA study. In addition, there have been recent claims made by a few individuals that the ISO 14040: 2006 series "has proven to be an appropriate tool for sustainability assessment." According to Fava et al. (2009), ISO 14040 ought to serve as the foundation for any subsequent LCA research.

According to a number of studies, the LCA ISO 14040 standard is the instrument that is utilized most frequently in the agri-food industry in order to investigate the effects that a product has on the surrounding environment over the course of its whole life cycle. LCA ISO 14040 consists of four main phases: (1) goal and scope, which is the essential component of the LCA, (2) qualitative and/or quantitative inventory analysis of the used resources and the emissions released from the life cycle of a product, (3) life cycle impact assessment, which can be divided into classification, characterization, and evaluation, and (4) the interpretation, which involves the identification of key issues, evaluation (including checking completeness, sensitivities, etc.), and the application of the findings. The specifics of each stage are broken down in the following sections.

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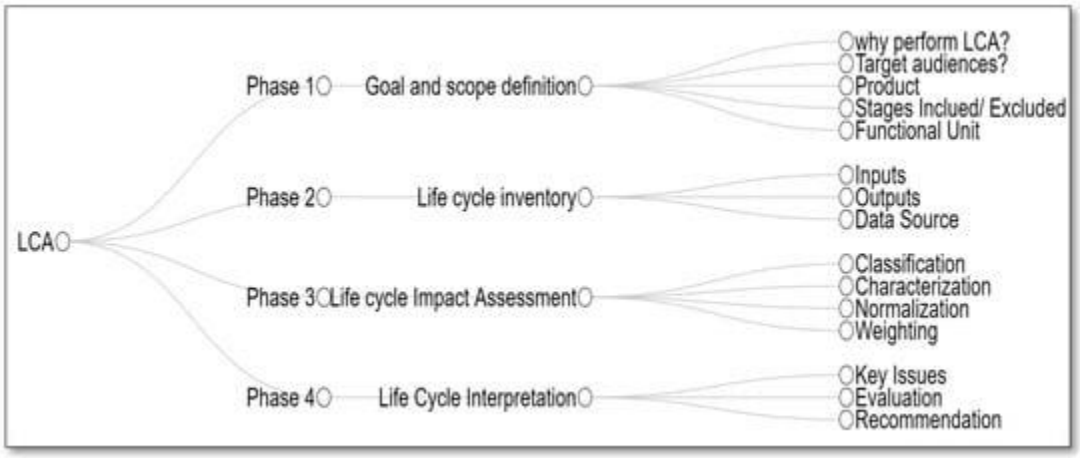

Figure 3. An overview of the phases of the life cycle assessment (LCA)

Goal and Scope Definition

According to Lee and Inaba (2004), in order to set up the aim, the following questions should be addressed: why perform LCA, who is the target audience, and what is the product that is the subject of the LCA study? These were recognized from the publications that were read when looking over the first phase of the LCA, which is presented in Figure 4. The findings of some of the studies addressed these problems head-on, while others went around and around in circles. The most frequent responses to each question are depicted in Figure 5, Figure 6, and Figure 7, respectively.

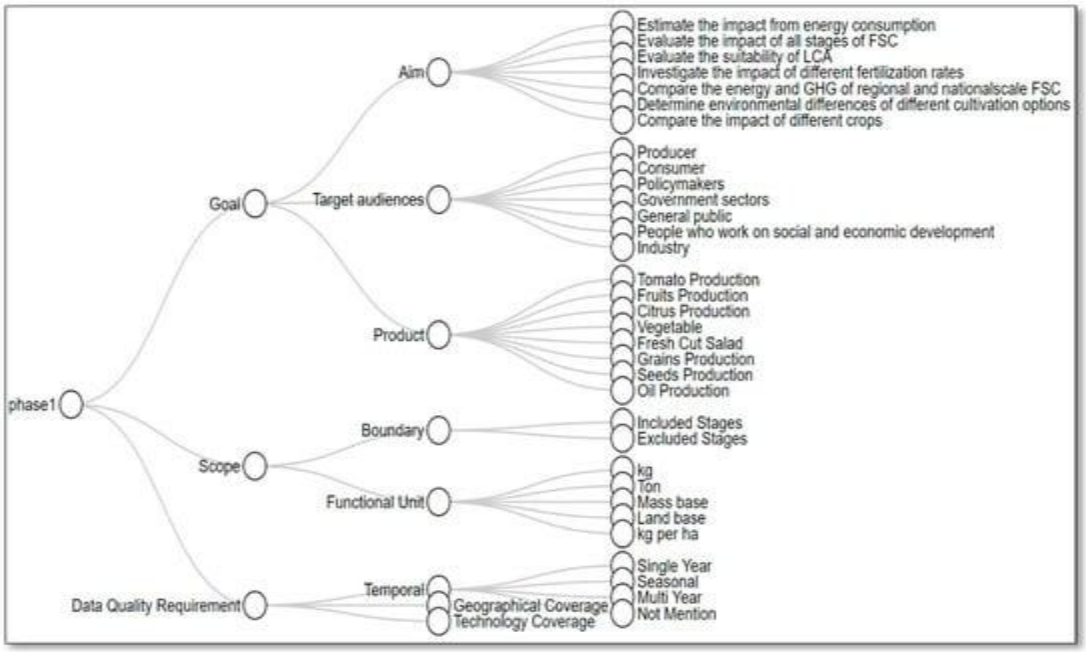

Figure 4. Life cycle assessment (LCA) begins with Phase 1, which focuses on goal and scope defining

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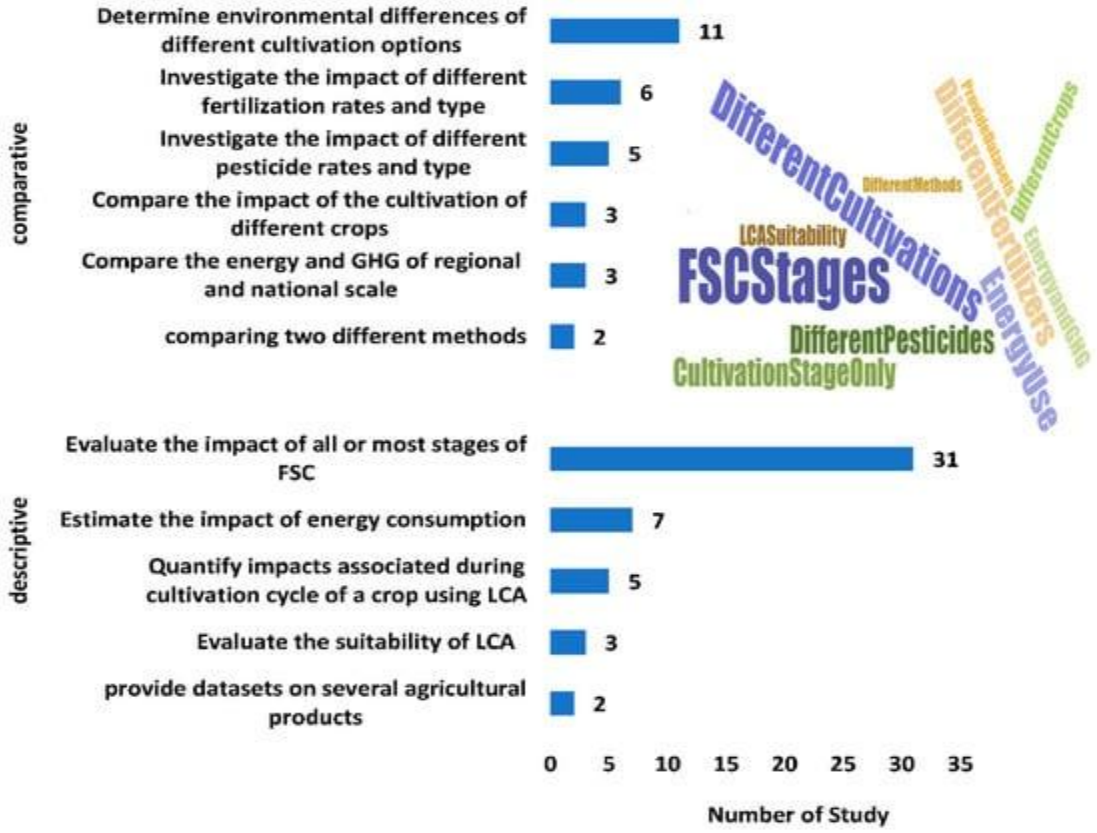

Figure 5. Representation, both quantitative and qualitative, of the overall goals of LCA as found in the research literature

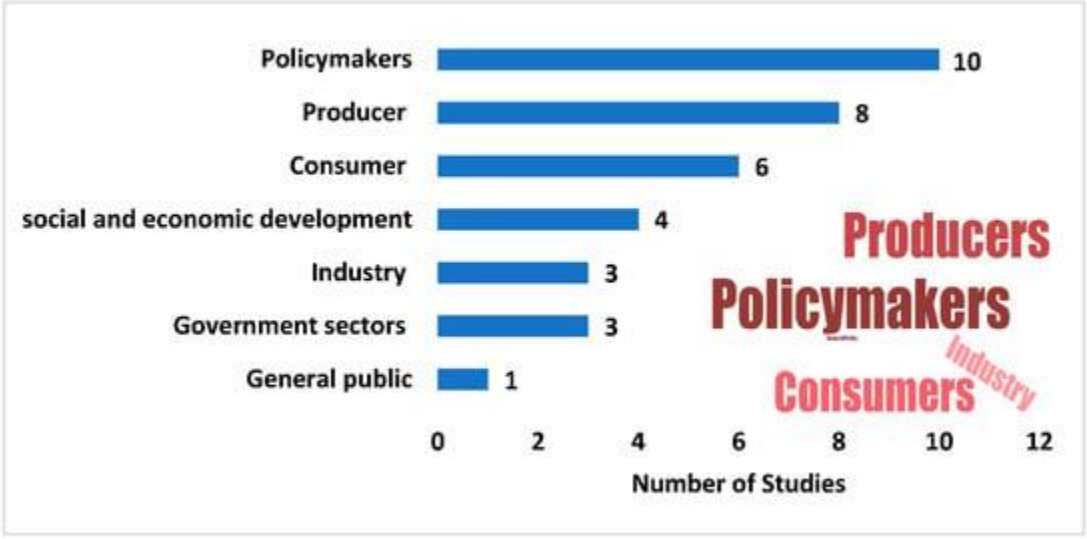

Figure 6. The literature presents its target audiences in the form of bars (for quantitative analysis) and a word cloud (for qualitative analysis)

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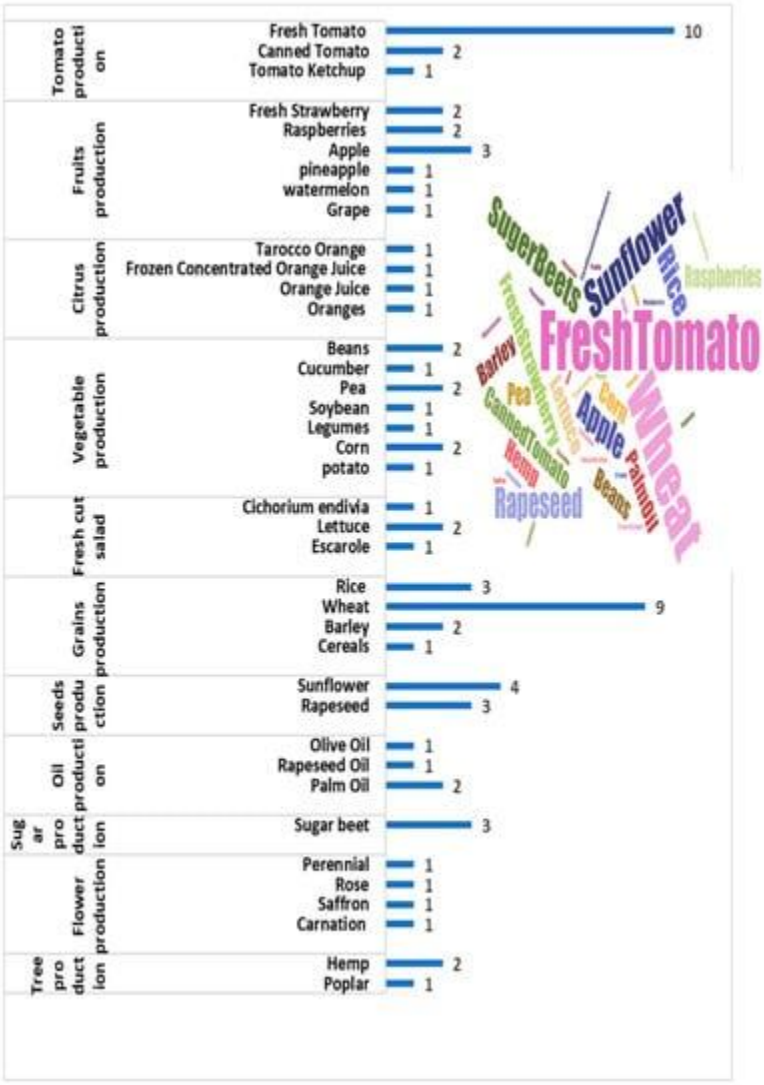

Figure 7. Products from the land that are typically considered in LCA analyses

Target Audience

Who conducts or commissions a life cycle assessment and for whom is determined by the target audience. It is essential to gain an understanding of who will use the results of the LCA in order to deliver the appropriate information to that audience. The vast majority of pieces of writing have more than one target audience (TA). The most common types of TAs, with 10 studies, were politicians working on climate change, decision-makers, and policymakers on global warming potential (GWP) footprints related to food and common agricultural policy (CAP). In addition, other studies aimed their attention at government sectors, such as those responsible for formulating food policy, the agriculture sector of the country, and the fruit and vegetable sector. After that, eight studies focused on the producers, specifically the farmers and the producing industry. Of these eight studies, six supplied information to the customer on a local and international scale. those working on

social and economic development, such as government policymakers for sustainable consumption and production, future ecolabelling initiatives, and those seeking to improve the environmental and financial sustainability of existing agricultural systems, were also targeted. This includes those working in the field of sustainable consumption and production. The Florida agricultural, agri-food, and citrus sectors constituted another segment of the audience we were looking to reach. The 74 research articles that were examined all made their intended readership very apparent. A word cloud representation of the frequency of target audiences is also provided for the purpose of providing a quick overview.

Agricultural

Tomato, fruit, citrus, vegetable, fresh salad, grains, seeds, oil, sugar, flower, and trees are the 11 categories into which we sorted the products. Tomato was the most often researched product, with 13 separate studies looking at various aspects of tomato production. These aspects included fresh tomato, canned tomato (whole peeled, paste, and diced), and ketchup. Wheat was the second most prevalent product, accounting for nine of the experiments. The fact that several studies focused on more than one crop explains why the same reference was used for multiple crop groups. It also explains why the number of studies displayed on the chart is greater than the number of studies that were actually covered. As shown in the diagram, the production of tomatoes was divided into three distinct groups since there are three distinct types of tomato products that were taken into account: fresh tomatoes, canned tomatoes, and tomato ketchup.

CONCLUSION

In conclusion, the environmental impact assessment of the solid wastes generated by the pesticide sector reveals a scenario that is both complex and alarming. Waste products generated by industries sometimes contain harmful chemicals and pollutants, which can represent serious threats to ecosystems, as well as to human health and the natural balance of the environment as a whole. The accumulation of waste materials that are not capable of biodegradation not only endangers the quality of the soil and the water resources, but it also adds to the pollution of the air by causing the release of harmful chemicals during the processes of incineration or decomposition. The long-term effects of these activities highlight the critical urgency of the need for stricter regulatory measures, improved waste management systems, and the promotion of sustainable alternatives within the pesticide business. In order to effectively address the environmental problems caused by pesticide waste, a multi-pronged strategy is required. This strategy must involve collaboration between industry stakeholders, government agencies, and scientific communities. The goal of this approach is to lessen the negative effects of pesticide waste and preserve the delicate balance of the ecosystems on our planet for future generations as well as those living today.

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